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Perceptions of Forest Change in the Governmental Region of Kaffrine, Senegal

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PERCEPTIONS OF FOREST CHANGE IN THE GOVERNMENTAL REGION OF KAFFRINE, SÉNÉGAL

By

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List of Abbreviations

ANSD - Agence Nationale de la Statistique et de la Démographie

CSÉ – Centre de Suivi Écologique

FAO – Food and Agriculture Organization of the United Nations

FMNR – Farmer Managed Natural Regeneration

GFW – Global Forest Watch

IUCN - International Union for the Conservation of Nature

LEK – Local Ecological Knowledge

NGO – Non-governmental Organization

PCMI – Peace Corps Masters International

PCR – Rural Council President

PCV – Peace Corps Volunteer

WCRP – World Climate Research Program

Abstract

Sénégal is a semi-arid West African country with a diverse ethnic makeup and a rapidly growing population that is largely rural, predominantly employed within the agricultural sector, and heavily reliant on the harvesting of forest products within state owned forests where populations have usufruct rights. The country experienced significant changes in land cover throughout the 20th century due to a series of major droughts and large expansions in agriculture. These changes were partially concentrated throughout the region of Kaffrine, where the wooded savannas of the early 20th century were systematically replaced by agriculture and converted to a shrub and tree savanna through over exploitation (Tappan et al. 2004). In the early 21st century this trend reversed, as the area of lands under cultivation in the Kaffrine region dropped from an estimated 434,121 hectares to 144,619 hectares between 2009 and 2014 (ANSD 2010; ANSD 2015). This study evaluated perceptions of local populations and key informants regarding trends in forest cover within the region of Kaffrine from the 1980s through 2017 and compared those perceptions to remotely sensed data of tree cover loss and extent from Global Forest Watch over a similar period. Semi-structured interviews covering a range of topics regarding forest change and forest resources were conducted with local populations and key informants (Eaux et Forêts officials) within each of the four departments of Kaffrine. Local communities did not prove to be a good judge of overall forest increases or decreases within their departments (nor did they accurately estimate precipitation trends), except for the areas immediately surrounding their communities. However, local knowledge regarding changes in tree species abundance was a reasonable reflection of agroforestry trends, and locals understood connections between forests, precipitation, harvesting, and food security. Additionally, key informants proved to be lacking in up-to-date data regarding the state of forests within the region, and they appeared to have a pronounced lack of influence within local communities. Going forward, relationships need to be further developed between local communities and Eaux et Forêts to ensure better management of forest resources surrounding villages, where forests and woodlands experience heavy anthropogenic pressures.

1 OBJECTIVES

The Sénégalese administrative region of Kaffrine is located within the semiarid sub-region of the western Sahel (Chamani et al. 2018). The Sahel region experienced significant droughts during the period of 1968 to 1984, with a 30% decrease in rainfall compared to the 1950s (Held 2014). More recently, Sénégal experienced significant droughts in 2014 and late 2017 (Peyton 2018; Sidibe 2017).

The Sahel is projected to experience temperature increases of 3-4°C by the end of the century, with an increase in the frequency of extreme hot seasons and a decline in precipitation, specifically in the western Sahelian region (Buontempo 2010).

Within the recent past, the Sahel has experienced a decline in natural vegetation due to declines in rainfall, and increasing pressures on natural resources due to population growth (Bakhoum et al. 2012a; Brandt et al. 2014a; Gonzalez 2001; Gonzalez et al. 2012; Herrmann & Tappan 2013; Nicholson 2000). More recently, a re-greening of vegetation has been noted throughout the Sahel and Senegal. Although there has been a noted increase in vegetative cover, woody vegetative cover is still far from recovering to pre-drought conditions and there have been significant transformations in the amount of natural vegetation, tree density, and tree diversity (Brandt et al. 2014a; Faye et al. 2018; Walther 2016).

The focus of this thesis is the utility of local population and key informant perceptions as a proxy for environmental assessment, specifically deforestation. The objectives of this study are to investigate:

1. Woody cover trends throughout the region of Kaffrine over the past 20-30 years (1987-2017) and 10-15 years (2002-2017) through local perceptions;
2. Whether data from remote sensing can verify the accuracy of local population perceptions in regards to forest changes over the past 10-15 years;
3. What perceptions people hold regarding the causes of deforestation or reforestation;
4. Whether certain tree species are decreasing, or no longer present, on the landscape;
5. Whether there have been changes in the amount of shade, wildlife abundance, or the distance to collect fuelwood over the past 10-15 years (all proxies for forest cover);
6. What actions, if any, people have taken to mitigate these changes.

2 GENERAL BACKGROUND

Figure 2.1 *Members of author's host family in Mouille, Kaffrine, Sénégal (photo by author).*

From the end of 2015 through 2017, I served as a Peace Corps Volunteer (PCV) in Sénégal, West Africa, in the Peace Corps Master's International (PCMI) program at Michigan Technological University. Through Sénégal's Ministry of Environment and Protection of Nature, I was assigned to serve as an agroforestry extension agent in Mouille, a rural village in the Kaffrine region. My primary responsibility was to promote the adoption of agroforestry technologies to Sénégalese farmers, and to increase the sustainability of agroforestry systems as a method of combating food insecurity in rural Sénégal.

While that sounds nice and impressive, it does not paint an accurate description of my work, my experiences, or my life in Sénégal. Nothing does. No words I use to describe my experience come close to what it was like or how it felt. Perhaps though, that is true for all the great experiences of life.

In September of 2015, heart pounding, palms sweating, fingers shaking, I boarded a plane with around 60 other idealistic, adventurous, and lovable fools. Over the next three months, we endured hours of technical, language, and cultural training. We struggled with learning to tell people our most basic thoughts. We became temporary members of

host families during Community Based Training, and all our comfort barriers and boundaries were broken down as we were given new names and developed new identities.

In December, I watched the Peace Corps car drive away. I was terrified and alone, as I was left at a new site with another new name, and once again, a new identity. I struggled. I questioned. I failed. I failed over and over again. But I also grew, and I became someone new. I learned. I spent time with people, sitting in people's huts, becoming a part of their lives and theirs becoming a part of mine. Eventually I started to work too. I instructed community members on how to incorporate trees into their agricultural systems, and how it could bring benefits to their lives. I still struggled. I experienced lows that nothing in life had previously prepared me for. I had highs too. I have never felt more welcomed, wanted, and celebrated, than every single time I rode my bike into village after having been away, and all the neighborhood kids would run into the street chanting my name. Thank you for that.

I lived. I lived all the gross, the welcoming, the terrifying, the fulfilling, the exhausting, the nerve wracking, the wonderful, the euphoric, the grim, and the frustrating. All of it. I lived it, and I hated it, and I loved it.

I can assure you that Peace Corps is not for everyone. Sometimes, I was not even positive that Peace Corps was for me. Even so, or perhaps because of it, I would do it all again in a heartbeat.

Where in the midst of all this, did I manage to propose a Master's thesis project and collect data for it? Well, truthfully, for a long time I had no idea. Two years sounds like a long time, up until you have already been telling yourself for a year that two years is a long time. I came up with a few preliminary proposals, but nothing felt right, and more importantly, nothing felt achievable. I stressed about it, but as previous PCMIs had told me time and time again that it would – eventually, my project came to me.

A few months into my time at site, I can recall spending time with my younger host brother, Souleymane. We talked about how in his short lifetime he had observed the receding of the trees from the village boundary to a spot far off in the distance. Souleymane was only 15 at the time; luckily, he spoke as much English as I spoke Wolof, and his observations may have been exaggeratory, but the conversation, and his perception of the changes within his environment, stuck with me.

When it came time to present thesis topic proposals to my advisor, I was grasping at straws. I threw forth a couple of ideas that I thought sounded nice but that I wasn't actually that motivated about, and also threw in a proposal regarding local thoughts of forest changes based on my conversation with Souleymane and comments made by other members of my community. I had not thought that my advisor would give the proposal serious consideration, but now looking back, and reflecting on her work and interests in landscape ecology and the social sciences, I should have known that it would spark her

interest, and I am glad that it did. Having one last opportunity to travel to new areas, experience Sénégalese teranga, spend time with my fellow PCV's that I was about to depart from, and have deep conversations with people about a topic that I truly cared about was a welcome close to my time in Sénégal.

3 SÉNÉGAL BACKGROUND

3.1 Description

Figure 3.1 *Location of Sénégal in Africa. Sénégal is highlighted in red. Used under Creative Commons 3.0 (for permission, see Appendix I).*

Sénégal, formally known as the République du Sénégal, is located along the Atlantic coast within Francophone West Africa. It is the most westerly-located country on the mainland continent, with Pointe des Almadies in Dakar extending out into the surf of the Atlantic. Sénégal is bordered to the north by Mauritania, to the east by Mali, and to the south by Guinea and Guinea-Bissau. Following the meandering of the Gambia River, the country of The Gambia is located within, and almost entirely encompassed by Sénégal.

A former French colony, Sénégal was granted its independence on 4 April 1960. Sénégal has had four presidents since then, acting as both head of state and head of government within the presidential republic political system. Léopold Sédar Senghor was Sénégal's first president. He served over 20 years in office, having first been elected in 1960, and

then again in 1963, 1968, 1973, and 1978. He was followed in office by Abdou Diouf, who served just over 19 years in office from 1981 to 2000, and Abdoulaye Wade, who served 12 years from 2000 to 2012 (The World Factbook 2018). Macky Sall is the current president, having been elected in 2012, and was also re-elected for a second term in 2019. Sénégal is often looked to as a model for successful post-colonial democratic transitions and remains one of the most stable democracies on the African continent, despite conflicts that have taken place in the southern Casamance (The World Factbook 2018).

Figure 3.2 *Regions of Sénégal. Used under Creative Commons 3.0 (for permission, see Appendix I).*

Sénégal has a total land area of 196,889.7 sq. km (19,688,970 hectares), making it similar in size to the North American state of South Dakota. The country is divided into 14 regions (Figure 3.2): Ziguinchor, Dakar, Thiès, Diourbel, Tambacounda, Fatick, Sédhiou, Kaolack, Saint-Louis, Kédougou, Matam, Kolda, Louga, and Kaffrine. The regions of Sédhiou, Kédougou, and Kaffrine were formed as recently as 2008. The country is further subdivided into 45 departments and 103 arrondissements, or districts (The World Factbook 2018).

The country's gross domestic product composition by sector is dominated by services (58.8%), followed by industry (24.3%), and agriculture (16.9%). Even so, 77.5% of Sénégal's labor force works within the agricultural sector, while only 22.5% of the labor force works within industry and services. This is because approximately 70% of Sénégal's population resides in rural areas where the primary source of employment is

related to agriculture. The main agricultural products produced within Sénégal are peanuts, millet, corn, sorghum, rice, and cotton (The World Factbook 2018).

3.2 People

3.2.1 Population Statistics

According to The World Bank Group (2018), the total population of Sénégal during 2017 reached 15.85 million. Approximately 30% of this population resides in urban centers concentrated in the west of the country, such as Dakar, Pikine, Touba, and Thiès, with the remaining population, approximately 70%, residing in rural areas (The World Factbook 2018).

Table 3.1 *Sénégalese population age structure based off 2017 estimates from The World Factbook 2018.*

Age Class (years)	Percentage
0-14	41.51%
15-24	20.33%
25-54	31.19%
55-64	3.98%
≥65	2.98%

Sénégal's population is currently growing at a rate of 2.8% annually, with the majority of its population being under the age of 25 (Table 3.1). Sénégal's high population growth rate is the 25th highest in the world, driven by its high fertility rate of approximately 4.28 children born per woman. This high fertility rate is due to an inclination towards large families in rural populations, early childbearing ages, and low rates of family planning (The World Factbook 2018). Culturally, it is common practice for girls to be married and having children prior to the age of 18, sometimes as young as 14. Men typically wait to marry until they have worked long enough to be able to afford a bride price. Additionally, polygamy is frequently practiced throughout Sénégal with men commonly having 1-4 wives, dependent on their wants, beliefs, and financial status. As an example of a typical family structure in Sénégal, my host family consisted of my father, Babacar Mbaye, and his two wives, Ge Cissé and Fatou Touré, both of whom bore him seven children. My host brother Hussein, his wife Xodja, and my host brother Abdou's wife, Naxeyna (along with their five children), also lived in our compound. This reflects the typical West African concept of family, consisting of a patriarch with one or multiple wives and their children, as well as the wives and children of the patriarch's sons, and any unmarried daughters (Abdullah 2008).

Life expectancy in Sénégal is typically in the 60s, ranging from 62.1 to 66.7 years, with females tending to live longer than males (The World Factbook 2018; UN DESA 2015; WHO 2016).

3.2.2 Education System

Figure 3.3 *Students at Mouille's primary school during a tree seed collection and storage training hosted by the author (photo by author).*

The Sénégalese education system is based on the remnants of the French colonial education system and consists of pre-primary, primary, secondary, and tertiary levels. It begins with pre-primary school (école pré-primaire) which is noncompulsory and free. Pre-primary education constitutes three years of study, and children can be enrolled from the ages of 3-5. Upon successful completion of pre-primary school, children can enroll in primary school (école primaire) at the age of six. Primary school consists of six grades and once students obtain their Certificate of Completion of Elementary Studies they are able to pass onto the secondary level (école secondaire) which consists of college, three grades, and lycèe, three grades. Eleven years of primary and secondary education are compulsory, and free, for children within Sénégal. The tertiary level of education refers to attending university (UNESCO-IBE 2010).

Table 3.2 *Percentage of net enrollment, based off 2016 education statistics from The World Bank Group, of Sénégalese students at pre-primary, primary, secondary, and tertiary levels.*

Education Level	Female (%)	Male (%)	Total (%)
Pre-primary	15	13	14
Primary	76	69	72
Secondary	18	23	20
Tertiary	8	12	11

Based on a report from The World Bank Group (2016), only 14% of Sénégalese children take advantage of the pre-primary level of education (Table 3.2). This is likely due to a lack of access to pre-primary school facilities, as students can attend at no cost. If a pre-primary school is not located directly in the village in which the pre-primary age children reside, they are unlikely to be able to attend a pre-primary school outside of own their community due to travel, time, financial, and familial constraints. A pre-primary school had been built in my community, Mouille, a few years prior to my arrival. Many families sent their pre-primary aged children to the school as it kick-started their education and allowed the women to have a few hours per day when they did not have to provide care for their 3-5 year old children. Unfortunately, the school was often closed during the school year due to a lack of available teachers.

The World Bank Group (2016) reported net enrollment at the primary education level as 72%, with over 650,000 children considered truant, and a 59% completion rate at this education level. Net enrollment at the secondary level of education significantly dropped to 20%, likely due to education no longer being compulsory or free after the completion of 11 years of primary and secondary levels of education. School life expectancy (primary through tertiary education levels) totals only nine years for both male and female students (The World Factbook 2018). This all culminates into literacy rates of 43-57.5% for the adult population, age 15 and over, with males having greater literacy rates than women at 53-69.7% and 34-46.6%, respectively (World Bank Group 2016; The World Factbook 2018).

3.2.3 Ethnic Groups

Throughout Sénégal, there is a large diversity of ethnic groups, with the Wolofs making up the ethnic plurality at approximately 37% of the population (The World Factbook 2018), nearly 5.8 million people. Due to their prevalence throughout Sénégal, and historical factors including the transatlantic slave trade, the Wolof language has become the most widely spoken language in Sénégal, and the lingua franca of business, despite French being the national language. While Wolofs make up the ethnic plurality in Sénégal, they are considered a minority in the few other countries in which they reside, including The Gambia and Mauritania. The origin of the Wolof people is greatly debated, with speculations ranging as far as ancient Egypt, present-day Libya, Morocco, and Yemen. There is common agreement that the Wolof people comprise of a mixture of

multiple groups that once occupied the fertile lands of the Sahara, including the Fulani (Pulaar), Mandé, Serer, Berbers, and Toucouleurs (Tukulors). In order to escape the effects of desertification, their ancestors began migrating south as early as 525 BCE, and they eventually came to settle in the area of present day Sénégal (Abdullah 2008).

Figure 3.4 *Fulani woman in the village of Katakel. Photo by Susan Rodriguez (for permissions see Appendix I).*

Additionally, Sénégal's ethnic makeup includes 26.2% Fulani, 17% Serer, 5.6% Mandinka, 4.5% Jola, 1.4% Soninke, and 8.3% other (The World Factbook 2018). The Fulani (also referred to as Fulbe, Fula, Peul, or Pël) are one of the largest ethnic groups in the Sahel, with their entire population of 38-40 million people spread across 20 countries throughout West, Central, and Eastern Africa (Nyuyki 2017). A majority of the Fulani are semi-sedentary and sedentary people that practice farming or live in urban areas. However, an estimated third of the Fulani are pastoralists mainly practicing transhumance, moving livestock from one grazing ground to another seasonally; they are the largest pastoral nomadic group in the world (Levinson 1995). The Serer ethnic group, comprising the third largest ethnic group in Sénégal at a population of approximately 1.84 million, are mainly concentrated in the western portion of Sénégal, in the regions of Fatick, Kaolack, Thies, and Diourbel. Populations of the Serer ethnic group can also be found outside of Sénégal in The Gambia and Mauritania (Berg & Wan 2009). The Mandinka (also known as Malinke, Maninka, or Mandingo) are part of the Mandé linguistic family that includes Soninke and Bambara ethnic groups, among others. In total, their population numbers near five million (less than a million in Sénégal), spanning across multiple West African countries including Guinea, Côte d'Ivoire, Mali,

Sénégal, The Gambia, and Guinea Bissau (Abdullah 2008). In Sénégal, the Mandinka people are predominantly located in the region of Tambacounda, the northern Casamance, and the eastern portion of the region of Kaffrine (Berg & Wan 2009).

3.2.4 Religion and Religious Education

Figure 3.5 *Woman praying. Photo by Susan Rodriguez (for permissions see Appendix I).*

Currently, Sénégal's religious makeup consists of 96.1% Muslim, 3.6% Christian, and 0.3% animist or traditional religions (The World Factbook 2018). Exposure to Islam began during the early reign of the ancient Ghana Empire between 700 and 1240 CE, but it was not until the eighteenth and early nineteenth centuries that jihadist movements created structural changes by overturning old caste systems and aristocracies in many West African societies that allowed for widespread conversion from traditional belief systems to Islam (Abdullah 2008). The Fulani, with their wide range across West Africa and other parts of the African continent, as well as their nomadic practices, were the first West African group of people to convert to Islam. According to Levinson (1995), this early adoption of Islam "increased the Fulanis' feeling of cultural and religious superiority to surrounding peoples, and that adoption became a major ethnic boundary marker." The Fulani led numerous jihads (holy wars) across West Africa, at times working with Arabian and Berber Islamic religious leaders to promote the spread of

Islam (Vikør 1999). Many Wolofs were converted to Islam during the eighteenth and early nineteenth centuries due to the widespread jihadist movements of warring Muslim factions from Mauritania. This mass conversion to Islam, coupled with a strong Muslim resistance to French colonization during the nineteenth century, led to the development of a strong Muslim identity amongst the Wolofs as well as the Mandinka, but in a more puritanical sense (Abdullah 2008). While the Serers were subjected to jihads from the Wolofs and the Mandinkas during the mid-nineteenth century, they strongly resisted the conversion to Islam. It was not until the late-nineteenth century that approximately 40% of the Serers identified as Muslim, and by the 1990s, Islam among the Serers had increased to approximately 80%. The remainder of the Serer population held onto their traditional beliefs or converted to Christianity, making up a large portion of Sénégal's Christian population (Olson 1996).

Koranic schools, non-centralized religious schools that teach children the values of Islam, are prominent throughout Sénégal, as well as other Muslim countries of the Sahel. They are often viewed as being more in line with Sénégalese traditional values compared to state schools that are sometimes viewed as vestiges of colonization. There are several differing types of Koranic schools, from informal village schools without precise timetables or curriculum, to formal Franco-Arab schools and universities. Despite not having a precise curriculum or timetable, Koranic schools are recognized as having three levels: primary, secondary, and higher studies. The primary level consists of students learning a basic knowledge of the Koran, mainly through the recitation of passages. The secondary level is reached once students have memorized large portions of the Koran and they then begin to translate passages from the Koran. Higher studies are typically only achieved by a few students and consist of studying under a distinguished religious scholar at an Islamic university. In Sénégal, it is not uncommon for male children to be fostered out to marabouts (Islamic religious leaders) to receive a religious education in a daara; a Koranic school where the students also live. Students of this type are referred to as talibé, and part of their religious education includes begging for food and receiving corporal punishments in order to foster humility and solidarity. A minority of students attending Koranic school are of this type; many students attend state schools and simultaneously attend Koranic school after state school has finished for the day, or during state school vacations (André & Demonsant 2014).

Koranic and formal state schools do not necessarily compete for enrollment amongst students despite both institutions being considered as credible education choices. Approximately 50% of girls and 40% of boys in Sénégal have never attended Koranic school. The majority of students that attend Koranic school do so for 2-3 years, with only 15% of girls and 20% of boys attending for more than 3 years. Children that have never attended Koranic school have lower state school enrollment rates than those that have attended Koranic school for a few years. However, after four years of Koranic schooling for boys, and three for girls, the proportion of students also attending formal state schools significantly decreases (André & Demonsant 2014).

3.3 Climate and Topography

Sénégal has relatively little topographic relief; approximately 75% of the country is at or below an elevation of 50 m above sea level. The region of Kedougou contains its highest point at 581 m, in the foothills of the Fouta Djallon mountain range (CSÉ 2015). The geological structure of Sénégal is composed of a sedimentary basin of sandstone that has more recently been covered with water and wind deposited sediments, as well as intermittent plateaus that are topped with lateritic hardpan (CILSS 2016).

The Sénégalese climate is typified as Sudano-Sahelian (CES 2015), as Sénégal is commonly classified as a transition zone within the southern range of the Sahel and the northern range of the Sudanian region. Chamani et al. (2018) divides Sénégal into two sub-regions of the Sahel: the arid sub-region and the semiarid sub-region. The northern half of Sénégal, north of Dakar, is within the arid sub-region and is typified as having an average monthly rainfall of less than 50 mm. The semiarid sub-region relates to the portion of Sénégal south of Dakar, and receives between 50 and 100 mm per month on average. Annually, the drier north receives <500 mm of rainfall, while the more humid south receives >1,000 mm of rainfall (CES 2015). Generally speaking, 1,000 mm of annual rainfall is the lower limit for self-sustaining forest, and savanna predominates in areas receiving between 750-1,000 mm of rain; trees cannot grow without irrigation in areas receiving less than 750 mm of rainfall per year (Mayer & Henareh 2011).

Seasons within Sénégal are determined by three factors: the West African monsoons that bring up humid air from the south between April and October, the seasonal movement of the Inter-Tropical Convergence Zone, and dry harmattan winds from the northeastern Sahara (Buontempo 2010). These three variables are responsible for the duration and intensity of the rainy season with strong southeast monsoon winds from June to October, and the dry season with hot dry harmattan winds from November to May (CES 2015).

During the period of 1968 to 1984, the Sahel region experienced significant long lasting droughts, with a 30% decrease in rainfall compared to the abundant rains of the 1950s, causing famine and severe economic losses (Held 2014). Severe drought events occurred intermittently throughout the 1990s, and most recently in Sénégal there were significant droughts in 2014 and late 2017 (Sidibe 2017; Peyton 2018).

Long-term climate model projections for the Sahelian region show little agreement due to the multitude of complex variables affecting climatic factors. Temperature projections are more certain than precipitation projections, with temperatures predicted to increase 3-4°C by the end of the century, which is greater than the projected average global increase. The largest proportion of this warming is expected to take place over the western Sahel, where Sénégal is located, with extreme hot seasons projected to increase in frequency as well. Although there is less consensus on projected precipitation levels, there is agreement that the western Sahel is also likely to experience decreases in summer precipitation (Buontempo 2010).

3.4 Forest Policy

Prior to colonial rule, the use of forests and forest products was monitored and sanctioned by village chiefs. Although it was within the village chief's jurisdiction to decide how the forests were utilized, they did not have ownership of the forests. The community collectively owned the forests. Factors such as ancestral village residence and social and familial networks within the village determined forest access and use (Faye et al. 2018).

Under the French colonial administration, all commonly owned forests were legally transformed into state property, giving the state exclusive control of their management. Many areas that had previously been commonly owned were classified as forest reserves, while areas not classified as such were managed with the intention of providing raw materials to French industries, most importantly timber (Faye et al. 2018).

Since the 1940s, charcoal production has been the main income-generating forest product in Sénégal. At this time, the National Forest Service (Eaux et Forêts) started to regulate forest use through a system of permits that were allocated to merchants, to ensure that urban demands for forest products, especially charcoal, were met. Quotas and licenses to produce charcoal were allocated to merchants on a restrictive basis. Many merchants had strong social and political ties to other pre-established and powerful merchants, or within the Ministry of the Environment. Eaux et Forêts typically denied licenses to village-organized groups on the presumption that they required training, and if they were allowed to produce charcoal before acquiring training, they would not learn to do it correctly (Faye & Ribot 2017).

After Sénégal gained its independence from France in 1960, the new government replicated the colonial land policy. The government kept formerly common lands under state control by denying private land rights to anyone that did not have a private title, or could not demonstrate long-term investments into the land such as having constructed buildings or planted trees on the property. Under this regulation, approximately 95% of national territory came under state control, with the rural populations given usufruct rights to the lands that they had previously commonly owned (Faye et al. 2018).

In 1996, the Sénégalese government went through decentralization reforms that were the culmination of a long process of disengaging the state that had been initiated through Structural Adjustment Programs under the President Abou Diouf (Ece 2017). Decentralization transferred authority to the regional and local governments, making local communities the primary actors and decision makers regarding nine areas of responsibility. One of those areas of responsibility was the management of the environment and natural resources (Diaw 2006). This reform process created Rural Communities, comprised of a cluster of multiple small villages, with democratically elected Rural Councils. Each Rural Council had an elected Rural Council President (PCR). Newly renamed community forests, although still under the state domain, were placed under the management of the Rural Councils. The state maintained exclusive management rights for classified forests and forest reserves (Faye et al. 2018).

In 1998, Sénégal's forestry code was updated to be in line with the 1996 decentralization. The updated forestry code gave Rural Communities, through the Rural Councils, further rights by allowing them to decide if their forests would be cut, which enterprises would operate within their forests, and who would have the rights to cut and commercialize them (Faye & Ribot 2017). Eaux et Forêts' roles included: maintaining an advisory role for the Rural Communities by training Rural Councils regarding forestry laws and regulations; increasing the technical and financial capacity of Rural Councils; facilitating financial support for the design, planning, and implementation of forest management plans; distributing a percentage of taxes gained from forest products to Rural Communities; and increasing women's involvement in natural resource management. The state was also in control of law enforcement, budget allocation, and supervising Rural Councils' decision-making processes (Diaw 2006).

Although Rural Councils had been given these rights, they were given in name only. Many Rural Councils chose to forgo harvesting for charcoal production in their community forests shortly after receiving their right to do so. In response to this decision, a regional deputy director of Eaux et Forêts stated that, "The resource is for the entire country. To not use it, there must be technical reasons. The populations are there to manage. There is a national imperative. There are priorities of the state. This cannot work if the populations pose problems for development." Many PCRs reported being coerced into authorizing charcoal production in their community forests against their wishes (Faye & Ribot 2017).

Diaw (2006) stated that rural communities have not successfully fulfilled their roles as managers of their community forests. He stated that the factors that contributed to this lack of fulfillment included: a lack of expertise within the Rural Communities to formulate a forest management plan; insufficient coordination within Rural Communities; Rural Communities not being aware of opportunities related to forest use; elected officials not taking responsibility for forest management; lack of access to financial resources; and short-comings of the local officials. The shortcomings of Eaux et Forêts were not mentioned.

Most recently in 2018, there was a call for a revision of Sénégal's forestry laws due to killings related to illegal timber trades ("Sénégal to revamp" 2018). My thesis work was completed prior to this new call.

3.5 Land Use and Cover Change

The Sahel region has undergone massive environmental changes within the recent past, including rapid natural vegetation decline, increased lands under cultivation, and shifts to more xeric tree species as an adaptation to more arid climates (Gonzalez 2001; Gonzalez et al. 2012; Bakhoum et al. 2012a; Herrmann & Tappan 2013). Recent studies (Salack et al. 2018; Chamani et al. 2018) have reported an expansion of the Sahel due to severe drought, decreases in annual rainfall, and increased anthropogenic activity, resulting in southward shifts in woody species distributions as well as declines in natural vegetation.

This is in part due to the Sahel experiencing the largest decline in rainfall recorded in the world since the late 1800s (Nicholson 2000), as well as increased anthropogenic pressures on natural resources due to population growth (Brandt et al. 2014a). These trends across the Sahel remain consistent in Sénégal where there were four serious droughts during the 20th century (Tappan et al. 2004) and where the population doubled over the period of 1945-1988 (Gonzalez 2001).

In 2011, Sénégal's land cover comprised of 46.8% agricultural lands, 43.8% forest, and 9.4% other (The World Factbook 2018). Forests are not defined in terms of percent forest cover or tree density, but this land cover category includes all land with a higher density of trees than found on savanna, which is a separate category. Peanuts, or groundnuts, dominate the agricultural landscape in Sénégal, particularly in the central western part of the country, accounting for 40% of lands under cultivation in 2010 ("Polishing Peanuts" 2015). The French colonial government introduced peanuts to Sénégal in the 1840s due to a demand for raw materials in the oil industry. The production of peanuts facilitated agricultural expansion through a large portion of Sénégal, resulting in a reduction of fallow and forested lands (Mbow et al. 2008). To achieve good yields, peanuts need between 500-700 mm of rain. Production has been devastated in the past due to frequent droughts, most recently in 2002 and 2011 ("Polishing Peanuts" 2015).

Figure 3.6 *Young boy in the Kaffrine department standing next to harvested peanut plants (photo by author).*

There have been multiple studies looking at changes in land cover over time in Sénégal. The most comprehensive study comes from Tappan et al. (2004). They evaluated land cover changes within the 13 pre-established ecoregions of Sénégal (DAT et al. 1984), over the 40-year period of 1965 to 2000 through satellite imagery and aerial surveys. They found that while significant changes in land cover had occurred in individual ecoregions throughout the country, the overall national trends were relatively stable, showing only slight to moderate change. The most change was due to agricultural expansion; 17% of land was under cultivation in 1965, increasing to 19.8% in 1985, and 21.4% in 2000. Between the period of 1965 to 1985, agricultural land increased by a rate of 27,715 hectares per year, and 20,573 hectares per year over the period of 1985 to 2000. Declines in the savanna (conglomerate of shrub savanna, shrub and tree savanna, and wooded savanna) and forest classes occurred during this time, from 73.7% to 69.6% for forests and 4.4% to 2.6% for savannas. Combined, this was a decline of savanna and forest class types by 33,000 hectares per year.

These figures are slightly less than figures reported by the United Nations Food and Agriculture Organization (FAO). Prior to 1990, forest area in Sénégal was declining at a rate of 52,000 hectares per year, increasing to 80,000 hectares annually throughout the 1990s (FAO 1995; 2010), although this was revised downward to a more conservative annual rate of forest cover decline of 45,000 hectares per year for 1990-2000, and a decline of 43,000 hectares per year for 2000-2010 (FAO 2011). More recently, re-greening trends have been identified in the Sahel through remote sensing studies, including in Sénégal (Faye et al. 2018; Brandt et al. 2014a). Although a re-greening has been observed, woody vegetation cover is still far from pre-drought conditions, and there have been significant transformations regarding decreases in biodiversity, natural vegetation, tree density, and tree species diversity (Walther 2018; Mbow et al. 2015; Brandt et al. 2014a; Herrmann & Tappan 2013; Gonzalez et al. 2012).

4 KAFFRINE BACKGROUND

4.1 Description

Figure 4.1 *Location of Kaffrine in Sénégal. Used under Creative Commons 3.0 (for permission, see Appendix I).*

The region of Kaffrine is located in central Sénégal (Figure 4.1), in an area referred to as Saloum in Wolof, or in English, as either Eastern Saloum or the Peanut Basin. Formerly a part of the region of Kaolack to the west, Kaffrine, along with the regions of Sédhiou and Kédougou, was designated as a distinct region in 2008. It is bordered to the north by Matam, Louga, Diourbel, and Fatick, the west by Kaolack, the south by The Gambia, and the east by Tambacounda.

Figure 4.2 *Departments within Region of Kaffrine, Sénégal. Used under Creative Commons 3.0 (for permission, see Appendix I).*

Kaffrine is divided into four departments, Birkelane, Kaffrine, Malem Hodar, and Koungheul (Figure 4.2), named for each of their departmental capitals. The departments are further subdivided into nine arrondissements (or districts), and then further into local collectives. Departments are also broken into communes and rural communities, which are the electing bodies within the region.

4.2 People

In 2014, the population of the region of Kaffrine was estimated to be 587,946, which is approximately 3.7% of the country's population. The population of Kaffrine is more youthful than that of the population throughout the country, with an average age of 20. Approximately 48% of the population is under the age of 15, and 66.7% is under the age of 25 (ANSD 2015).

The region of Kaffrine is the least urbanized region within Sénégal, with 15.1% of the population residing in urban locales while the remaining 84.9% are considered rural. The main economic activity within the region is rain fed agriculture with 75% of the population taking part, followed by livestock breeding, exploitation of forest products, and trade (ANSD 2015).

The dominant ethnic group throughout the region is Wolof, at approximately 74% of the population. The remaining ethnic groups include Fulani, Mandinka, Serer, and Bambara. Islam is the majority religion (ANSD 2015).

In Kaffrine, 3,083 students were enrolled in pre-primary education in 2014. Fifty-five percent of the students were girls. The number of primary education students in the region was 52,503 in 2014 (55.9%); this was a 5.2% increase from enrollment in 2013 with the largest increase seen within the private education system. The Agence Nationale de la Statistique et de la Démographie (ANSD 2015) reported that following the completion of primary education, girls had a 16.8% dropout rate, compared to 14.5% of boys.

4.3 Climate and Topography

The climate of the region of Kaffrine is Sudano-Sahelian. Kaffrine experiences an average amount of interannual rainfall, about 640 ± 171 mm annually (Bakhoum et al. 2012a). The rainy season occurs from June to October, with strong southeast monsoon winds, and the dry season follows from November to May with hot dry harmattan winds (CES 2015). The average annual temperature is 26.8ºC with monthly average maximum and minimum temperatures at 30.4ºC in May and 24.2ºC in January ("Climate Data" 2012).

The total land area of the region of Kaffrine is 1,132,289 hectares. The average elevation throughout the region is 21.25 m ("Climate Data" 2012).

4.4 Forests

There are 13 protected forest areas within the region of Kaffrine amounting to 251,850 hectares, or 22% of the regional land area. Eleven of these protected forest areas are considered classified forests, while the remaining two are sylvo-pastoral reserves. Seventy-three percent (183,900 hectares) of these protected forest areas are located within the department of Malem Hodar; the remaining 27% are distributed across the departments of Koungheul (36,000 hectares), Kaffrine (23,850 hectares), and Birkelane (8,100 hectares). Each department has an Eaux et Forêts office that manages the protected forests in their department and works with the Rural Communities to manage their community forests (ANSD 2015).

Figure 4.3 *The fruit of Cordyla pinnata being prepared for cooking. Photo by Susan Rodriguez (for permissions see Appendix I).*

While the region is closed to logging, a significant amount of income is brought in through the exploitation of forest products such as fuelwood, charcoal, the collection of native fruits, the collection of traditional medicinal products, and hunting. Knowledge regarding the fauna of the region is limited, specifically regarding the state of change of current populations. Bird species dominate the fauna in the region with double-spurred francolins (*Pternistis bicalcaratus*), African grey hornbills (*Lophoceros nasutus*), Abyssinian rollers (*Coracias abyssinicus*), Senegal coucals (*Centropus senegalensis),* helmeted guinea fowls (*Numida meleagris*), common quails (*Coturnix coturnix*), chestnut-bellied sandgrouse (*Pterocles exustus*), multiple dove and pigeon species, and many others. The presence of large and medium sized mammals is known to be decreasing throughout the Sahel and West Africa, even within most protected areas (Hema et al. 2017; Walther 2016). This trend is believed to be occurring in the region of Kaffrine as well (ANSD 2015). Mammal species currently present include spotted hyenas (*Crocuta crocuta*), common warthogs (*Phacochoerus africanus*), Senegalese wolves/grey jackals (*Canis anthus anthus/Canis aureus anthus),* stripped ground squirrels (*Xerus erythropus*), and various species of rabbits. This decrease is attributed to the deterioration of forest area due to frequent droughts, extensive farming, expanding human populations, and wildfires (ANSD 2015).

4.4.1 Wildfires

Similar to other regions of Sénégal, Kaffrine is extensively affected by wildfires. Wildfires lead to a scarcity of forest resources and the disappearance of wildlife species due to habitat destruction.

Table 4.1 *Hectares of land affected by wildfires in the region of Kaffrine by year, based off ANSD reports 2010-2015.*

	2010	2011	2012	2013	2014	2015
Hectares	6,484	10,231.5	2,772	3,085	1,942	9,842

Throughout the period of 2009 and 2014, the area of land affected by wildfires varied greatly (Table 4.1). In 2015, most of the wildfires occurred in the Kaffrine departments of Malem Hodar and Koungheul.

It is the role of Eaux et Forêts to manage wildfires, but there are also 282 community wildfire control committees in the region: 115 in Koungheul, 76 in Kaffrine, 50 in Malem Hodar, and 41 in Birkelane. In 2014, only 38 of these committees throughout the region had adequate equipment and training for fighting wildfires (ANSD 2015).

4.4.2 Reforestation Efforts

Sénégalese forest policy promotes reforestation as a means of combating desertification. The amount of seedlings produced for reforestation efforts have fluctuated significantly from 2009 to 2015 in the region of Kaffrine (Table 4.2). These include nurseries produced by the government, Rural Communities, villages, private individuals, and schools.

Table 4.2 *Number of tree seedlings produced for reforestation campaigns in the region of Kaffrine by year, based off ANSD reports 2010-2015*

	2009	2010	2011	2012	2013	2014	2015
Seedlings	868,290	213,540	1,833,670	621,906	2,135,319	740,156	779,408

During the 2014 reforestation campaign, 52% of seedlings were produced by village nurseries. These seedlings were used to reforest 607 hectares in plantation-style plantings, an increase of nearly 216% from 2013. The number of hectares reforested for conservation and restoration declined by 98.2% in the same period within the region (ANSD 2015). It is important to note that the number of seedlings produced and the amount of hectares reforested with seedlings does not equal tree survivorship. The number of trees that survive six months to one year after outplanting is often much lower than the amount of seedlings outplanted.

4.5 Land Use and Cover Change

Prior to the agricultural transformations of the 20th century, the natural vegetation throughout the region of Kaffrine was a dry Sudanian woodland dominated by *Combretum glutinosum* and *Combretum nigricans*. Other common tree species included *Cordyla pinnata, Adansonia digitata, Bombax costatum, Pterocarpus erinaceus, Lannea acida, Anogeissus leiocarpus, Sénégalia macrostachya, Sclerocarya birrea, Strychnos spinosa, Crossopterix febrifuga,* and *Feretia apodanthera* (Trochain 1940).

Figure 4.4 *Individuals descending from a collection of harvested peanuts in Mouille, Kaffrine, Sénégal (photo by author).*

Today, the main economic activity within the region is rain-fed agriculture. The main food crops produced in the region include peanuts, millet, sorghum, and maize. Kaffrine is the leading peanut producing region in Sénégal, making up 21.7% of national production. As of 2014, 45.7% of reported farming households (n = 43,916) cultivated 1-5 hectares of land, 32.1% cultivated 6-10 hectares of land, and 5.2% cultivated twenty or more hectares of land. The Sénégalese national average for farming households with 20 or more hectares of land under cultivation is 2.6%. Of all the cultivated areas under production, 52.1% of them are utilized to produce peanuts (ANSD 2015). While land under cultivation decreased from 2010 to 2014, in 2015 there was a sudden expansion of cultivation, almost reaching levels in 2011 (Table 4.3). This increase is attributed to a combined effort of the state and nongovernmental organizations in the area to increase agricultural activities through the increased subsidization of fertilizer and seeds, and making 30 tractors and 2,300 seed drills available to farmers (ANSD 2015).

Table 4.3 *Hectares of land under cultivation in the region of Kaffrine by year, from ANSD reports 2010-2015.*

	2010	2011	2012	2013	2014	2015
Hectares	434,121	409,269	334,576	334,519	329,991	407,428

4.5.1 Ecoregions

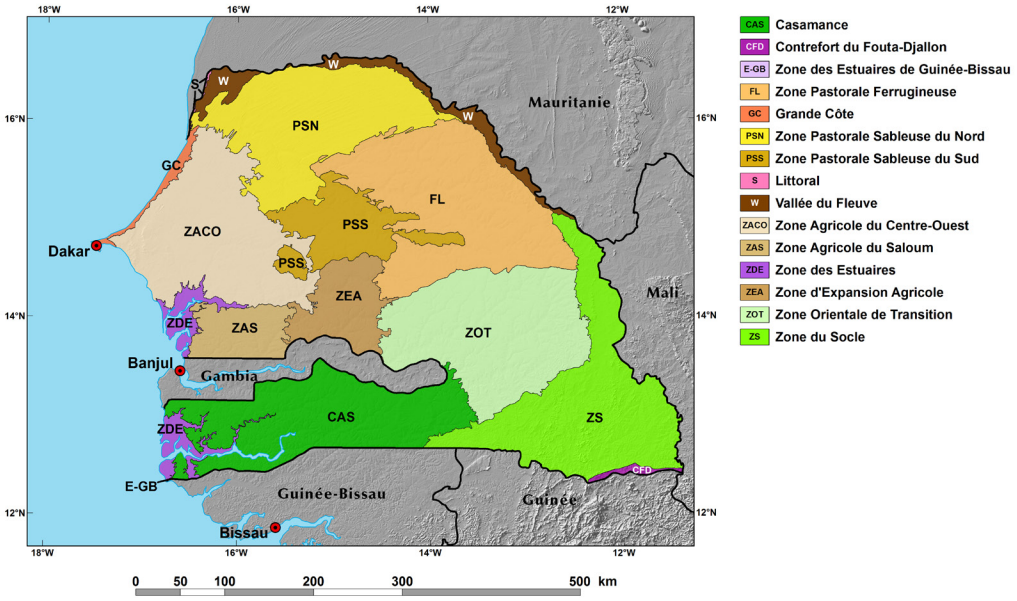

Figure 4.5 *Ecoregions of Senegal. Image is within the public domain (for permission, see Appendix I).*

My study area and the majority of the region of Kaffrine is located within the Agricultural Expansion Ecoregion/Zone d'Expansion Agricole (ZEA) (Tappan et al. 2004). Portions of Kaffrine, to the west and north, also reside within the Saloum Agricultural Ecoregion/Zone Agricole du Saloum (ZAS), West Central Agricultural Ecoregion/Zone Agricole du Centre-Ouest (ZACO), and Southern Sandy Pastoral Ecoregion/Zone Pastorale Sableuse du Sud (PSS) (Figure 4.5). The ZEA, ZAS, & ZACO ecoregions comprise Sénégal's Peanut Basin.

The ZEA, ZAS, and PSS ecoregions all experienced increases in lands under cultivation and decreases in amounts of woody cover during the latter half of the 20th century. The ZACO ecoregion differs, as cultivated lands initially increased before reaching a peak and then returning to mid-20th century levels (Table 4.4).

Figure 4.6 *Young man in ZEA (department of Kaffrine) preparing field for planting at the beginning of the rainy season (photo by author).*

During the latter half of the 20th century, the wooded savannas that were the dominant vegetation type of the ZEA were mostly lost to charcoal production and a conversion to agriculture. By 2000, the dominant vegetation type had been converted from wooded savanna to shrub and tree savanna (Tappan et al. 2004). These findings were supported by Mbow et al. (2008) who showed through the use of Landsat imagery that between 1988 and 2000 agricultural lands in this area had increased by 58%, with a similar decrease of 56% noted in savanna cover types. Tappan et al. (2004) predicted that in the future, the agricultural expansion rate in this ecoregion would slow as most of the soils suitable for agriculture were already under cultivation.

Within the ZAS, there was a nearly complete transformation to agriculture from Sudanian woodlands throughout the 20th century. Peanut production within the ecoregion began during the period of 1900-1940, and then greatly expanded between 1950-1960. This growth slowed but did not cease throughout the rest of the century. The woodlands throughout the ZAS experienced significant declines in woody cover during the latter half of the century (Tappan et al. 2004).

Within Sénégal, the ZACO is the ecoregion that has been the most fundamentally altered by human activity. Over the past 160 years, there has been a complete transformation

from woodlands and wooded savannas with small villages scattered throughout, to nearly continuous areas of agricultural cultivation under sparse parklands. In the 1980s, the amount of land under cultivation reached a peak at 80%. By the beginning of the 21st century, the amount of land under cultivation had returned to mid-20th century levels due to farmers abandoning agriculture for more economically lucrative activities and allowing their former agricultural lands to lie fallow (Tappan et al. 2004).

PSS is a part of Sénégal's sylvo-pastoral region with a dominant vegetative composition of shrub and tree savanna. In comparison to the ecoregions located within Sénégal's Peanut Basin, the PSS has had limited human settlement due to shallow soils and a deeper water table. Even with limited human settlement, lands under cultivation increased and woody cover decreased during the second half of the 20th century (Tappan et al. 2004).

Table 4.4 *Land use and cover changes through time within ecoregions located within the region of Kaffrine (Tappan et al. 2004).*

	1943	1965	1968	1984	1994	1999	2000
Agricultural Expansion Ecoregion (ZEA)		Agriculture 35.4%; Woody cover 20-30%			Woody cover 6-10% (<3% in cultivated areas)		Agriculture 64.6%
Saloum Agricultural Ecoregion (ZAS)	Woody cover 40-70% in woodlands		Agriculture 61%		Woody cover <2% throughout ecoregion	Agriculture 69%	Woody cover 10-20% in woodlands
West Central Agricultural Ecoregion (ZACO)		Agriculture 67%		Agriculture 80%			Agriculture 67%
Southern Sandy Pastoral Ecoregion (PSS)		Agriculture 1.2%; Woody cover 15-20%			Woody cover 5-15%	Agriculture 16.5%	

5 LITERATURE REVIEW

Local ecological knowledge (LEK) and the perceptions of local populations can be utilized as a means of conducting ecosystem assessments. This knowledge is based on direct interactions that people have with their local environments as well as their trial and error experiences over time. LEK incorporates cultural, social, and political knowledge, and is frequently formed through group perceptions. Although local populations hold a wealth of knowledge regarding their environment, caution must be taken to ensure that they, and their knowledge, are not exploited for the pursuit of academia (Chalmers & Fabricius 2007).

Several previous studies have demonstrated that LEK of deforestation and other natural resource trends can be fairly accurate and reliable. In South Africa's Wild Coast, Chalmers & Fabricius (2007) assessed LEK regarding changes in forest and woodland cover over a period of 30 years through interviews with local experts (recognized as such by community members) and senior members of the general population, while also analyzing land cover through aerial imagery. Local expert understanding of forest change was remarkably consistent with the aerial imagery assessment, although senior members of the general population had a less nuanced understanding of the scope of change.

Within the Similipal Tiger Reserve in India, Sahoo et al. (2013) evaluated the understanding of local residents' perceptions of declines in wildlife and forest cover over a 20-year period, through open-ended interviews conducted in the local language. Information on forest cover loss within the reserve was obtained from the Forest Survey of India. The results of the study indicated that local residents had a strong understanding of changes in wildlife populations and forest cover over time.

A study by Boissiere et al. (2013) evaluated the way that residents of the Mamberamo watershed in Papua, Indonesia perceived seasonality, climate variability, and climate change within the context of their environment through semi-structured interviews. Those perceptions were then contrasted with previously recorded local climate and meteorological data. Local residents' perceptions were able to effectively gauge seasonality, climate variability, and climate change within their surrounding environment.

In northern Senegal, Gonzalez et al. (2012) found that observations of tree density by local residents from 1954-2002 were consistent with findings obtained from field measurements and remote sensing. Local perceptions, especially those of women that collected fuelwood, were used by Faye et al. (2018) to assess forest cover decline and the simultaneous re-greening of the vegetative landscape in the region of Tambacounda. Brandt et al. (2014a) also detected a re-greening trend in the Sahel through remote sensing, specifically in Linguère, Senegal and Bandiagara, Mali. Field investigations revealed that this trend was a simulated re-greening due to farmer managed agroforestry and the spread of robust species such as *Balanites aegyptiaca* that concealed decreases in natural vegetation, tree density and diversity. These findings were corroborated, and expanded on, through interviews with members of the local population. In the Sénégalese

Ferlo, Brandt et al. (2014b) utilized interviews with village elders to validate remote sensing and soil and woody vegetation model findings, such as an overall decline in woody species and tree cover.

Herrmann & Tappan (2013) examined changes in the composition and abundance of woody vegetation in an area covering parts of the regions of Kaffrine, Kaolack, and Fatick. They conducted woody vegetation inventories in 2010 at sites that were previously inventoried in 1980. For the same period, they obtained repeat photography at each of the sites and utilized LEK as complementary information regarding woody vegetation abundance, species richness, and change. Their results showed that despite greening trends noted through coarse resolution satellite imagery; there has been a general shift in the overall woody cover which was indicated by a reduction in woody species richness, a loss of large trees, an increase in shrub species, and a shift towards more robust, xeric species. The results of the forest inventory showed a complete disappearance of *B. costatum* and *P. erinaceus,* as well as high levels of decline in the species *L. acida*, *C. pinnata*, *A. leiocarpus*, and *Sterculia setigera*.

In the departments of Birkelane and Koungheul, Bakhoum et al. (2012b) used local perceptions of current woodland characteristics from 574 households in 40 villages to corroborate the results of forest inventories, showing that people had a strong understanding of the woodland characteristics, as their citations were congruent with the results of the forest inventory. People identified 140 tree species and revealed if they were most commonly found in fields, fallows, or forests. Seventy-five species were identified through the forest inventory. Thirty-seven of the species cited were also identified as being rare, or endangered, with *P. erinaceus*, *C. pinnata*, *Detarium microcarpum*, and *S. setigera* having been referenced as the most endangered. People reported that these tree species had multiple uses such as food, traditional medicine, fuelwood, and fodder, and stated that their threatened status was likely due to their overexploitation due to their various uses. Concerning all of the threatened tree species cited, people listed the threats to these trees as being overharvesting, wildfires, drought, and inappropriate cultivation techniques. People felt that the main consequences related to the disappearance of these species including decreased access to traditional medicine, low agricultural yields, decreased rainfall, and lack of wood products, fuelwood, and fodder. Reforestation, farmer managed natural regeneration (FMNR), prevention of wildfires, and increased awareness were listed as recommendations of solutions to the threatened status of these tree species.

Mbow et al. (2008) analyzed drivers of environmental change in the Eastern Saloum as well as the local perceptions of these changes through remote sensing data from 1989 and 1999, archival data, statistical data, and household interviews. They conducted 25 interviews/questionnaires in three villages near the regional capital of Kaffrine. People perceived environmental change as referring to decreased soil fertility and land degradation such as a decline in wildlife and the vegetation having degraded due to overuse, drought, and fires. There was also a belief that land far from settlements was improving, as land use pressure had decreased in recent years due to emigration. People

reported that they mainly utilized forest products from *A. digitata* and *C. pinnata*, although most people were unable to report on their use of forest products in the past. The people identified an erratic climate, agricultural policies, insufficient food production, and a desire to increase financial security as the drivers of these environmental changes. The authors of the study concluded that although the environmental changes in the area had been influenced by climate variability, the main drivers of the changes had been due to governmental interventions in agriculture as well as fluctuations in the global market.

The premise of the current study is well grounded as these multiple previous studies have displayed that LEK and the perceptions of local populations, globally as well as in Senegal and the region of Kaffrine, can be utilized as a means of conducting ecosystem assessments. The current study adds to this body of work as it investigates woody cover changes in the region of Kaffrine from 2002 through 2017, a period that has not previously been investigated; the perceptions of key informants (Eaux et Forêts) regarding perceptions of forest change and their interactions with local populations; the current state of vulnerable tree species on the landscape, which was last investigated in 2012 in the departments of Birkelane and Koungheul (Bakhoum et al. 2012b); local perceptions of causes of woody cover changes; the use of changes in shade, abundance of wildlife and distance to collect fuelwood as proxies for woody cover change; and actions taken by members of the local population to mitigate changes in woody cover.

6 METHODS

6.1 Study Sites

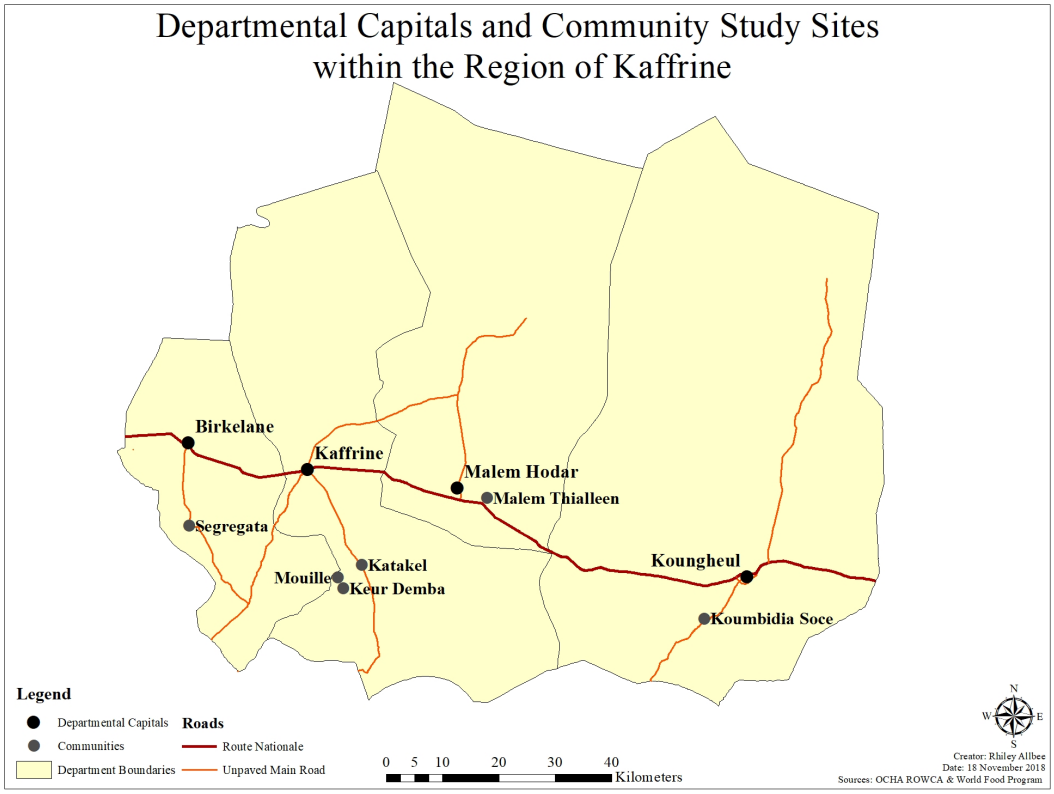

Figure 6.1 *Map of departmental capitals, major roads, and study sites within the region of Kaffrine, Senegal. Map created by author.*

Study sites were located within each of the four departments of the region of Kaffrine (Figure 6.1). I chose study sites based on their accessibility and the availability of an individual who was able to facilitate community introductions. Peace Corps volunteers working and residing in the villages of Koumbidia Soce, Malem Thialleen, and Segregata served as intermediaries, introducing me to interview subjects. Table 6.1 provides climate and demographic information for each department and community.

Table 6.1 *Characteristics of study area, by department and village.*

Location	Area (ha)	Elevation (m)	*Temperature (C)	**Rainfall (mm)	Population Size	Demographics	Dominant Ethnic Group
Department of Birkelane	112,449	7	27.2°; 30.2°; 24.5°	593	104,958	93% of population rural; 7% urban	
Segregata		27			1,050	60% of population female; 40% male	Wolof
Department of Kaffrine	247,665	15	27.4°; 30.2°; 24.1°	594	215,351	76% of population rural; 24% urban	
Mouille		8.9			1,200	299 men & 321 women >25; 4 boys & 13 girls 6-25; 323 boys & 301 girls 0-6	Wolof
Katakel		22			800	NA	Wolof
Keur Demba		25			400	NA	Wolof
Department of Malem Hodar	316,154	45	27.2°; 30.1°; 23.9°	619	98,160	91.7% of population rural; % urban	
Malem Thialleen		26.9			1,000	NA	Wolof
Department of Koungheul	456,020	18	27.5°; 31°; 24.2°	686	169,478	87.2% of population rural; 12.8% urban	
Koumbidia Soce		16.8			644	168 men; 138 women; 165 boys; 173 girls	Mandinka

*Average annual temperature; maximum monthly average temperature; minimum monthly average temperature
**Average annual rainfall

Figure 6.2 *Cart path to Mouille during the beginning of the dry season (photo by author).*

Within the department of Kaffrine, I interviewed local individuals in three villages: Mouille; Katakel; and Keur Demba.

Mouille is located 25 km south of the regional capital of Kaffrine, 20 km south along a main unpaved road and five kilometers southwest along a cart path through the bush. I lived with a Wolof host family in the village of Mouille throughout the duration of my Peace Corps service.

The village of Katakel is located 20 km south of the regional capital of Kaffrine along a major unpaved road that continues to The Gambia. The village of Katakel was included in the study as I had previously worked in the village and did not require an intermediary.

I visited Keur Demba to conduct an interview with an individual whom was identified in previous interviews as a local expert. Keur Demba is located 28.5 km south of the regional capital of Kaffrine, 22.5 km south along the main unpaved road, and 6 kilometers southwest along a cart path through the bush.

I visited Koumbidia Soce, a village predominately made up of the Mandinka ethnic group, in the department of Koungheul. Koumbidia Soce is located 12 km south of the departmental capital of Koungheul on a main unpaved road, and is located 102 km east of the regional capital of Kaffrine.

The village of Malem Thialleen is located five km west of the departmental capital of Malem Hodar along a cart path through the bush, and 38 km west of the regional capital of Kaffrine.

Segregata is located 10 km south of the departmental capital of Birkelane along a main unpaved road. It is located 35 km southwest of the regional capital of Kaffrine.

Figure 6.3 *Horse drawing a cart down the unpaved main road to Segregata during the beginning of the dry season (photo by author).*

6.2 Interviews

I conducted interviews in Wolof from October 2017 through November 2017. With the assistance of two host country nationals working as English teachers in the regional capital of Kaffrine, I translated interview questions into Wolof, and back-translated them into English, in order to ensure question integrity and clarity prior to conducting interviews. I selected respondents through a snowball sampling methodology, where one or more key individuals were identified through a pre-existing relationship with myself,

or a resident Peace Corps Volunteer. Upon completion of the interview, the respondent was asked to name others in the area that were knowledgeable on the subject matter of the interview (Bernard 1995).

I conducted 50 interviews with members of the local population within the four departments of Kaffrine (Table 6.2). Twenty-three of these interviews took place within the department of Kaffrine where I resided, the majority in my resident community of Mouille. The remainder of the interviews took place within villages of each of the remaining departments in the region of Kaffrine.

Table 6.2 *Total males and females within local population interviewed by location.*

Location	Male	Female	Total
Department of Birkelane			
Segregata	6	1	7
Department of Kaffrine			
Mouille	6	12	18
Katakel	3	1	4
Keur Demba	1	0	1
Department of Malem Hodar			
Malem Thialleen	6	4	10
Department of Koungheul			
Koumbidia Soce	8	2	10
Total	30	20	50

I also conducted interviews with an Eaux et Forêts staff member in each of the departments of Kaffrine (4 total, all male).

Interviews were semi-structured, allowing them to be open-ended whilst still following a general script, and effectively covering a series of topics (Bernard 1995). Topics investigated with members of the local population included: backgrounds/demographics; perceived forest changes; continuation of forest change and causes; effects of forest change on community; and actions taken to prevent forest loss (Appendix B.1). Topics investigated with Eaux et Forêts staff members pertained to: work backgrounds; roles of their office/organization; forest changes in their jurisdiction; impacts of forest change; and actions taken to prevent forest loss (Appendix B.2). I asked for perceptions of forest changes for the periods of 1987-2017 and 2002-2017. I utilized the period of 1987-2017 as it overlapped with previous studies that had investigated forest changes in the area and gave a view of people's perceptions over a longer period. Additionally, I utilized the period of 2002-2017 as forest changes had not previously been investigated over this period and I was able to corroborate these perceptions with remote sensing information obtained from Global Forest Watch (GFW) for the period of 2001 through 2017. After the initial question of perceived changes in woody cover, I only utilized the period of

2002-2017 as participants had difficultly answering questions over two time frames and this period has not been as thoroughly investigated.

I recorded each interview with the use of an audio recording device. Collectively, interviews lasted on average 21 minutes, and ranged from 10-42 minutes. Local population interviews lasted on average 20 minutes, and ranged from 10-42 minutes. Key informant interviews lasted on average 22 minutes, ranging from 11-27 minutes. Local population respondents ranged in age from 25 to 79, with an average age of 49. Eighty-four percent of respondents reported having not attended state school for any duration of time. Of the individuals that had not attended state school, 88% of them reported having attended Koranic religious school for a varying amount of years. A strong majority (78%) of local population respondents reported farming as their primary occupation. Except for the 10 respondents from Koungheul Soce whom identified as members of the Mandinka ethnic group, respondents identified as members of the Wolof ethnic group. I did not ask key informants about their ethnic identification. All key informants had a multiyear history of working for Eaux et Forêts, but duration of time working in the region of Kaffrine ranged from two months to five years.

The Institutional Review Board at Michigan Technological University approved questionnaires for the interviews for exemption (Reference number: M1648). I read a statement of oral informed consent (Appendix A) to each participant in his or her native language and it was agreed upon prior to the commencement of each interview.

6.3 Analysis

Following the completion of interviews, I translated recordings from Wolof to English and transcribed them. I coded these transcriptions with the use of NVivo 12 Plus (QSR International), a qualitative data analysis computer software program. Coding involves arranging and linking concepts, themes, or ideas into a systematic format, therefore allowing for qualitative analysis (Saldaña 2013). Nodes used for coding are located in Appendix C. Additionally, I utilized NVivo's auto-coding feature to code by interview question, allowing for easier cross comparison of responses from all respondents. I then used NVivo to identify trends and consistencies throughout the interviews with the use of frequency queries and crosstab queries, which allowed for cross tabulating the coding intersections between codes and attribute values. When looking at trends in perceptions of forest change, I evaluated participant perceptions on a regional and departmental scale.

Coded frequencies and results from crosstab queries were entered into Microsoft Excel, which was used to represent basic trends graphically as well as in tables.

6.3.1 Cluster Analysis

I sorted respondents into correlated groups by respondent to identify trends with the "Cluster Analysis" tool. I choose "Coding Similarity" and "Pearson Correlation

Coefficient" to create a dendrogram where the Pearson Correlation Coefficient was reflected in the hierarchical distance between clusters of respondents (that is, interviewees that responded to questions similarly). Clustering by respondent means that while each respondent is found in only one cluster, each of the nodes has the potential of occurring in multiple clusters of respondents. Ten clusters were produced with the Cluster Analysis tool. I used these clusters to guide further analysis of trends by identifying and analyzing the top nodes by percent node coverage for each respondent within the individual clusters. This allowed me to identify similarities of focus between respondents in each of the clusters.

6.3.2 Remote Sensing Data

An initiative of the World Resources Institute, Global Forest Watch (GFW) is an open-source web application for monitoring forests globally. Using Landsat satellite imagery, they have mapped global tree cover change from 2001 to 2017 and tree cover extent in 2000 and 2010, at a spatial resolution of 30 m. They define forest loss "as a stand-replacement disturbance or a change from a forest to a non-forest state" and forest gain as "the inverse of loss, or the establishment of tree canopy from a non-forest state." Tree cover is described as "canopy closure for all vegetation greater than 5 m in height (Hansen et al. 2013b)."

To corroborate local perceptions of forest change for the period of 2002-2017 I obtained data for the region of Kaffrine and each of its departments from GFW regarding:

1. Tree cover loss from 2001-2017 at >10% canopy cover;
2. Extent tree cover for 2000 and 2010 at >10% canopy cover;
3. Tree cover gain from 2001-2012 at >50% canopy cover.

Forest survey data was not collected as ground-truthing for the remote sensing data obtained through GFW, but verification was completed through other means (GFW 2014).

7 RESULTS

7.1 General Perceptions of Forest Change

> *"There were many trees here then. When you wanted to go to the field, there were many ndambal (Kigelia africana). Now, they are no longer found here, they have disappeared. It used to be dark under the trees, but now, people are cutting them for fuelwood. People do not have cook stoves, they do not have charcoal, and they do not have gas. They cut trees to cook with. They have taken them until none remain."*

Throughout the region of Kaffrine, there is a general perception that woody cover declined from 2002-2017, as well as 1987-2017. This is reinforced by perceived decreases in the number and abundance of tree species, wildlife, shade, access to forest products, and perceived increases in distances to collect fuelwood.

The department of Koungheul differs from the other departments within the region as the majority of respondents (70%) reported a perceived increase in woody cover from 2002-2017. The same proportion of respondents stated that an increase in shade had occurred, but 70% of respondents also reported increased distances to collect fuelwood over the same period. This could be due to a scarcity of dead wood, even though woody cover is increasing. Perceptions of the increase or decrease in wildlife abundance were split 50/50 in this department.

7.1.1 Forest Changes

7.1.1.1 Perceptions of Forest Change 1987-2017

Across the region, the majority of respondents (n=50) reported a perceived decrease in woody cover from 1987-2017 (Table 7.1). All respondents in the departments of Birkelane and Malem reported a perceived decline in woody cover over this time, with a respondent from the department of Birkelane stating,

> *"Yes. Trees were more abundant in the past. We used to have many trees here, but now they have decreased in the forest."*

Over 3/4ths of respondents from the department of Kaffrine reported a perceived decline in woody cover during this period:

> *"The trees have decreased a lot. This is because every day I need a little bit of fuelwood. I go and collect dry wood, but I have not yet planted live trees to replace what I took. This is part of why the trees are decreasing."*

"The trees in the forest? They have become much less abundant. All of them, all of them are gone. The trees, there are not many of them left in the forest."

Within the department of Koungheul, respondents' perceptions were more variable, with the majority (60%) reporting a perceived increase in woody cover from 1987-2002. A respondent from the department of Koungheul stated that,

"The trees are starting to come back now. A short time ago, they had all been cut for making charcoal. During the dry season, people would burn the forest, and all the trees would die. This happened a lot here. However, Eaux et Forêts came, and they taught us about protecting the forest. They helped us by bringing materials, and we were able to start making tree nurseries."

Table 7.1 *Local respondents' perceptions of forest change throughout the region of Kaffrine from 1987-2017, by department.*

Location	Decreased		Increased	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	7	100.0	0	0.0
Kaffrine (23)	18	78.3	5	21.7
Malem (10)	10	100.0	0	0.0
Koungheul (10)	4	40.0	6	60.0
Region (50)	39	78.0	11	22.0

7.1.1.2 Perceptions of Forest Change 2002-2017

The majority of respondents throughout the region of Kaffrine reported a perception of decreased woody cover from 2002 through 2017 (Table 7.2).

"The trees, they have become less abundant. You can plant trees, but people cut them. If the trees do not have protection, they will decline."

"Ten years past, the trees were more abundant. I have seen it, and so have others. The trees were more abundant then."

Respondents in the department of Koungheul reported a majority perception (70%) of increased woody cover for this time frame; this is a stronger perception than was displayed for the longer time frame from 1987 through 2017 (Table 7.1). One respondent in the department of Koungheul stated that,

"The trees have increased. The trees have started to return."

Table 7.2 *Local respondents' perceptions of forest change throughout the region of Kaffrine from 2002-2017 by department.*

Location	Decreased		Increased	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	7	100.0	0	0.0
Kaffrine (23)	17	73.9	6	26.1
Malem (10)	8	80.0	2	20.0
Koungheul (10)	3	30.0	7	70.0
Region (50)	35	70.0	15	30.0

7.1.1.3 Estimation of Forest Change

Forty-nine respondents gave estimations of forest change from 2002-2017 across the region of Kaffrine. Of those that reported a decrease in woody cover for this period (n=34), the majority (70.6%) reported that they had perceived the decrease to have been greater than half (Table 7.3).

> *"The decrease has been greater than half. In the past, when you sat here you were not able to see Mouille. Now, you can see everything. There were many trees then, but now they have decreased by more than half."*

> *"Yes, more than half. I think that if there had been one hundred trees before, there are only twenty left now."*

Similarly, of those that reported an increase in woody cover (n=15), the vast majority reported that they had perceived the increase to have been greater than half. One respondent reported that,

> *"In the bush, there are more trees now than there were before. They have increased by more than half."*

Table 7.3 *Local respondents' estimations of forest change from 2002-2017, by department.*

	Decreased					
Location	**More than Half**		**Half**		**Less than Half**	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	4.0	57.1	1.0	14.3	2.0	28.6
Kaffrine (15)	13.0	86.7	2.0	13.3	0.0	0.0
Malem (8)	4.0	50.0	0.0	0.0	4.0	50.0
Koungheul (4)	3.0	75.0	1.0	25.0	0.0	0.0
Region (34)	24.0	70.6	4.0	11.8	6.0	17.6
	Increased					
Location	**More than Half**		**Half**		**Less than Half**	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (0)	0.0	0.0	0.0	0.0	0.0	0.0
Kaffrine (7)	6.0	85.7	1.0	14.3	0.0	0.0
Malem (2)	1.0	50.0	0.0	0.0	1.0	50.0
Koungheul (6)	5.0	83.3	1.0	16.7	0.0	0.0
Region (15)	12.0	80.0	2.0	13.3	1.0	6.7

The majority of respondents reported that perceived forest changes had been greater than half over the past 10-15 years, regardless of whether they perceived the forest to have increased or decreased.

7.1.1.4 Perceptions of Change in Amount of Shade

I investigated respondents' perceptions of changes in the amount of shade across the landscape as a proxy for changes in woody cover across the landscape.

Local respondents' perceptions of changes in the amount of shade across the landscape (n=50) were congruent with perceptions of change in woody cover across the landscape. Most respondents reported a perceived decrease in the amount of shade across the landscape from 2002-2017 (Table 7.4). A respondent from the department of Kaffrine stated that,

> *"The shade is very far apart in the forest. As the trees decrease, the shade also decreases. The forest used to be dark with shade. Now, it is no longer dark."*

In the department of Koungheul, the same proportion of respondents reported a perceived increase in the amount of shade as had reported a perceived increase in the amount of woody cover. One respondent stated that,

> *"The shade has increased. Many people are starting to work with trees now because they know that trees have many uses. Previously, people here did not know about the importance of trees, but now they know. This is the reason that many people are starting to work with trees. This is the reason that trees are increasing and not decreasing."*

Table 7.4 *Local respondents' perceptions of change in the amount of shade across the landscape from 2002-2017, by department.*

Location	Decreased		Increased	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	6	85.7	1	14.3
Kaffrine (23)	18	78.3	5	21.7
Malem (10)	9	90.0	1	10.0
Koungheul (10)	3	30.0	7	70.0
Region (50)	36	72.0	14	28.0

7.1.1.5 Perceptions of Changes in Distance to Collect Fuelwood

I investigated respondents' perceptions of changes in distances to collect fuelwood as a proxy for changes in woody cover across the landscape.

The majority of respondents (n=50), throughout the region as well as in each of the departments, believed that distances for collecting fuelwood had increased from 2002-2017 (Table 7.5). A respondent in the department of Malem stated that,

> *"We do not have fuelwood here now; you have to walk five kilometers to find it. Before, you could find good fuelwood just outside the village and fill a cart with it. Now, you have to go five kilometers to find fuelwood."*

Table 7.5 *Local respondents' perceptions of change in distance to collect fuelwood from 2002-2017, by department.*

Location	Increased Distance		No Change	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	5	71.4	2	28.6
Kaffrine (23)	22	95.7	1	4.3
Malem (10)	7	70.0	3	30.0
Koungheul (10)	7	70.0	3	30.0
Region (50)	41	82.0	9	18.0

More women reported perceived increases in distances to collect fuelwood (Table 7.6) than they had reported decreases in woody cover or decreases in shade across the landscape. This is likely because within Wolof gender roles women are the primary collectors of fuelwood, therefore giving them a nuanced understanding of changes in fuelwood scarcity.

Table 7.6 *Local respondents' perceptions of change in distance to collect fuelwood from 2002-2017, by gender.*

	Increased Distance		No Change	
Gender	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Male (30)	25	83.3	5	16.7
Female (20)	16	80.0	4	20.0
	41	82.0	9	18.0

A total of 29 respondents reported their perceived distances needed to travel to collect forest products currently (2017), with 33 respondents also reporting how far they believed they needed to travel to collect forest products 15 years ago (2002) (Table 7.7). The discrepancy between how many people reported past perceived distances and current perceived distances is due to the open-ended nature of the interviews. Respondents' perceptions of the distance needed to travel to collect forest products increased from 2002-2017 in each of the individual departments, with the greatest perception of increase reported in the department of Malem, closely followed by the department of Koungheul.

Table 7.7 *Local respondents' perceptions of 2017 distances, 2002 distances, and the change in distances to collect forest products in their villages.*

Location	2017 Distance (km)		Location	2002 Distance (km)		
Department	**Average**	**Range**	**Department**	**Average**	**Range**	**Change in Distance (km)**
Birkelane (5)	2.8	1-5	Birkelane (6)	2.2	1-5	+0.6
Kaffrine (13)	9.7	2.5-30	Kaffrine (16)	7.9	2.5-30	+1.8
Malem (6)	7.2	3-20	Malem (4)	4.8	1.5-7.5	+2.4
Koungheul (7)	5	1.5-9.5	Koungheul (5)	2.8	1-8	+2.2
Region (29)	7	1-30	**Region (33)**	5.6	1-30	+1.4

7.1.1.6 Perceptions of Change in Wildlife Abundance

I investigated respondents' perceptions of changes in wildlife abundance across the landscape as a proxy for changes in woody cover across the landscape.

The majority of respondents (76%) across the region of Kaffrine (n=50) reported that the abundance of wildlife had decreased from 2002-2017 (Table 7.8). A respondent in the department of Kaffrine stated that,

> *"The animals have decreased because there are no longer many trees in the forest. In the past, when you went into the forest you would have to be alert for animals because it was dark and there were many of them, but now you no longer have to do this because they have lessened."*

Within the departments of Birkelane and Koungheul, approximately half of respondents reported a decrease in abundance of wildlife, while in the departments of Kaffrine and Malem the large majority of respondents (87-90%) reported perceived declines in wildlife abundance.

Table 7.8 *Local respondents' perception of change in abundance of wildlife from 2002-2017, by department.*

Location	Decreased		Increased	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	4	57.1	3	42.9
Kaffrine (23)	20	87.0	3	13.0
Malem (10)	9	90.0	1	10.0
Koungheul (10)	5	50.0	5	50.0
Region (50)	38	76.0	12	24.0

Respondents were not asked to identify which wildlife species that they perceived to be decreasing, but of the 38 respondents that reported a perceived decrease in wildlife abundance, eight identified specific wildlife species that they perceived to be in decline. The most frequently referenced species were spotted hyena (*C. crocuta*), double-spurred francolin (*P. bicalcaratus*), and chestnut-bellied sandgrouse (*P. exustus*) (Table 7.9). A respondent in the department of Birkelane reported that,

> *"The animals have decreased. The forest does not have wild animals. They are not here. There are no chestnut-bellied sandgrouse (P. exustus). There is nothing. There are no double-spurred francolins (P. bicalcaratus). There are no common warthog (P. africanus). In the forest, you do not see chestnut-bellied sandgrouse (P. exustus). They are gone. There are no longer many African savanna hares (Lepus victoriae). There are not many aardvarks (Orycteropus afer). We no longer have Guinea baboons (Papio papio). There used to be many animals here, now only spotted hyenas (C. crocuta) remain, but there are not many. There are no longer many animals in the forest."*

Of the 15 species that were identified, ten are of least concern on the Red List of Endangered Species by the International Union for the Conservation of Nature (IUCN), including the spotted hyena (*C. crocuta*), double-spurred francolin (*P. bicalcaratus*), chestnut-bellied sandgrouse (*P. exustus*), and common warthog (*P. africanus*). This designation is due to their wide geographic ranges. The spotted sandgrouse is no longer listed as extant in Senegal, although its overall population trend is listed as stable. The remainder of the species listed as of Least Concern have population trends that are labeled as being in decline or unknown. Guinea baboons (*P. papio*) are listed as near threatened due to a decrease in geographic range of 20-25% over the past 30 years. Their current population trend is unknown (IUCN 2018).

Three of the species identified by local respondents are designated by the IUCN (2018) as vulnerable with decreasing population trends: cheetahs (*Acinonyx jubatus*), African lions (*Panthera leo*), and leopards (*Panthera pardus*). Both African lions (*P. leo*) and leopards (*P. pardus*) are extant in Senegal, but their populations are small and concentrated near Niokolo-Koba National Park in the regions of Tambacounda and Kédougou. Cheetahs (*A. jubatus*) are guessed to have long been extinct in Senegal, but their extinct status was not confirmed until 2014 (IUCN 2018). Each of these species was identified by a different

local respondent in different departments: the cheetah (*A. jubatus*) was identified in the department of Malem; the African lion (*P. leo*) was mentioned in the department of Koungheul; the leopard (*P. pardus*) was cited in the department of Kaffrine. It is unlikely that these three species would have been present in the region of Kaffrine 15-20 years ago, although not impossible. It is probable that respondents mentioned these species as they were aware that they had been present in the area historically, even if their disappearance from the area did not fit into the period under question.

Table 7.9 *Wildlife species that are perceived to be decreasing, arranged by number of respondents that referenced the species as decreasing. "Respondents" is number of respondents that referenced the species as decreasing, and "References" is the total number of times a species was referenced as decreasing.*

Species	English Common Name	Wolof Common Name	Respondents	References
Crocuta crocuta	Spotted hyena	Bukki	5	5
Pternistis bicalcaratus	Double spurred francolin	Cokeer	5	5
Pterocles exustus	Chestnut-bellied sandgrouse	Naat	5	6
Phacochoerus africanus	Common warthog	Mbaam all bi	4	4
Orycteropus afer	Aardvark	Njaxat	2	2
Acinonyx jubatus	Cheetah	Tene mi	1	1
Canis anthus anthus/Canis aureus	Sénégalese wolf/grey jackal	Tilla	1	2
Genetta genetta	Common genet	Yoolaan	1	1
Lepus victoriae	African savanna hare	Lëg	1	1
Mellivora capensis	Honey badger	Kund	1	1
Panthera leo	Lion	Gaynde gi	1	1
Panthera pardus	Leopard	Segg	1	1
Papio papio	Guinea baboon	Baabun	1	1
Varanus exanthematicus	Savannah monitor	Mbëtt mi	1	1
Vulpes pallida	African sand fox	Wel	1	1

Of the 12 respondents who reported perceived increases in wildlife abundance, four identified three wildlife species as increasing (Table 7.10).

Table 7.10 *Wildlife species that are perceived to be increasing, arranged by number of respondents that referenced the species as increasing. "Respondents" is number of respondents that referenced the species as increasing, and "References" is the total number of times a species was referenced as increasing.*

Species	English Common Name	Wolof Common Name	Respondents	References
Crocuta crocuta	Spotted hyena	Bukki	2	2
Pternistis bicalcaratus	Double spurred francolin	Cokeer	1	1
Pterocles exustus	Chestnut-bellied sandgrouse	Naat	1	1

The spotted hyena (*C. crocuta*) was identified as increasing by two respondents in the department of Birkelane. The double-spurred francolin (*P. bicalcaratus*) was referenced as increasing by a respondent in the department of Koungheul, and the chestnut-bellied

sandgrouse (*P. exustus*) was referenced as increasing by a respondent in the department of Malem.

7.1.1.7 Changes in Tree Species Abundance

7.1.1.7.1 Decreasing Tree Species

All participants (n=50) stated that there are tree species that used to be located on the landscape that are no longer present, or that are now hard to find.

> *"There are many trees that we know of, but that we no longer have in the forest. Many trees have disappeared over the past twenty years or more."*

Of the 50 local respondents, 49 were able to name at least one tree species that had disappeared, or that was now difficult to find, on the landscape. The local respondents referenced declining tree species 266 times, culminating in a total of 74 tree species (Appendix D).

Table 7.11 *Tree species identified by four or more respondents as decreasing or having disappeared from the landscape, arranged by number of respondents that referenced the species as decreasing. "Respondents" is number of respondents that referenced the species as decreasing, and "References" is the total number of times a species was referenced as decreasing. Species listed in bold font are on the IUCN Red List.*

Species	Common Name (Wolof)	Respondents	References
Detarium microcarpum	**Dànq**	**19**	**28**
Pterocarpus erinaceus	**Win**	**18**	**27**
Parkia biglobosa	Néte, Wul	13	18
Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	10	14
Swartzia madagascariensis	Dimbeli	10	12
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	9	11
Lannea acida	Son	8	10
Cordyla pinnata	Dimb, Dimbu	7	11
Sterculia setigera	Mbép	6	8
Combretum glutinosum	Rat	5	5
Ekebergia senegalensis	**Xak cooy**	**5**	**6**
Hymenocardia acida	Enkeleñ	5	6
Adansonia digitata	Guy	4	4
Anogeissus leiocarpus	Ngejan, Gejj	4	4
Diospyros mespiliformis	Alom	4	4
Ficus iteophylla	Loro, Tat	4	6
Tamarindus indica	**Dakkar**	**4**	**4**

Of the 74 species referenced, 59 could be identified by their scientific names. Of these, 12 were listed on the Red List of Endangered Species by the IUCN (Appendix E), while the remainder are not located within the IUCN's database. *P. erinaceus* is the only species listed as Endangered, meaning that it has a high risk of extinction in the wild. The majority of the species are listed as Least Concern, meaning that the taxa is widespread

and abundant, including the species that were also referenced as declining on the landscape (IUCN 2018).

North of Kaffrine, in the region of Louga, the species *A. leiocarpus, Combretum micranthum, Grewia bicolor*, and *S. setigera* were identified by local populations as having disappeared, or strongly declined, over the past 40 years (Brandt et al. 2014a; Brandt et al 2014b). All these species, except *C. micranthum*, were also referenced as having declined on the landscape over the past 10-15 years in the present study, although *G. bicolor* was referenced only once.

In the region of Kaffrine, Bakhoum et al. (2012b) identified the following species as being considered the most threatened by local populations (ranked most to least threatened): *P. erinaceus, C. pinnata, D. microcarpum, S. setigera, B. costatum, Heeria insignis, Ficus iteophylla, L. acida, Diospyros mespiliformis*, and *A. leiocarpus*. Herrmann & Tappan (2013) also reported perceived declines in *B. costatum, P. erinaceus, L. acida, C. pinnata, A. leiocarpus* and *S. setigera* by local populations in the region of Kaffrine from 1983-2010. Local perceptions were confirmed through woody vegetation inventories, which verified that *B. costatum* and *P. erinaceus* had disappeared from all woody vegetation inventory sites by 2010. These findings are in line with the findings of this study, with all of these species having been referenced by at least four local respondents as being in decline or having disappeared from the landscape, except for *H. insignis*, which was referenced by three local respondents.

A larger range of tree species were identified in the present study as being in decline on the landscape than were mentioned in the previous studies. Additionally, there were species such as *Parkia biglobosa, Ficus gnaphalocarpa (Ficus sycomorus),* and *Swartzia madagascariensis* that were referenced at high frequencies in the current study as being in decline or having disappeared from the landscape, but that were not addressed in the previous studies. This likely indicates that since the completion of the previous studies, a larger proportion of tree species have come under threat, some to a greater degree than species that had been referenced as being threatened previously.

7.1.1.7.2 All Tree Species

Local respondents referenced specific tree species 918 times throughout interviews, culminating in 100 individual species (Appendix H). By far, the most commonly referenced tree species was *M. indica*, having been referenced 133 times (Table 7.12). This was followed by *C. pinnata* at 75 references and *A. occidentale* with 55 references. This implies that, although not native species, *M. indica* and *A. occidentale* are tree species that are highly valued by members of the local population throughout the region of Kaffrine. *C. pinnata* is the most highly valued native species by the local population, likely due to its use as a food source and its variety of other uses such as fencing, fuelwood, traditional medicine, and wood products.

Table 7.12 *The twenty-five most commonly identified tree species, arranged by number of references. "Respondents" is number of respondents that referenced the species as decreasing, and "References" is the total number of times a species was referenced as decreasing.*

Species	Common Name (Wolof)	References	Respondents
Mangifera indica	Mango	133	43
Cordyla pinnata	Dimb, Dimbu	75	31
Anacardium occidentale	Darkase	55	25
Pterocarpus erinaceus	Win	36	18
Psidium guajava	Guap	34	18
Detarium microcarpum	Dànq	29	18
Combretum glutinosum	Rat	27	21
Eucalyptus camaldulensis	Kotyl-buteel	26	16
Vachellia nilotica	Neb neb	26	13
Carica papaya	Papikaya	25	14
Citrus spp.	Limon	24	14
Ziziphus mauritiana	Sidéem	23	14
Parkia biglobosa	Néte, Wul	18	13
Leucaena leucocephala	Leucaena	17	6
Guiera senegalensis	Nger	16	13
Diospyros mespiliformis	Alom	15	11
Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	15	8
Lannea acida	Son	15	10
Piliostigma reticulatum	Ngiigiis	15	12
Sterculia setigera	Mbép	15	11
Adansonia digitata	Guy	14	9
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	14	10
Balanites aegyptiaca	Sump	13	9
Tamarindus indica	Dakkar	13	7
Anogeissus leiocarpus	Ngejan, Gejj	12	11

7.1.1.7.3 Increasing Tree Species

Respondents were not requested to name tree species that they believed to be increasing, but multiple respondents did of their own accord. Tree species that respondents perceived to be increasing were referenced 37 times by 15 respondents, for a total of 20 individual species (Table 7.12). Of those 20 species, 11 were also referenced as decreasing across the landscape. For example, while eight respondents believed that *C. pinnata* was increasing, seven respondents believed it to be decreasing. Additionally, three respondents believed *C. glutinosum* to be increasing, while five respondents believed it to be decreasing. A pattern did not emerge by department in which respondents thought these species were increasing versus decreasing.

Tree species that were identified as increasing but not decreasing, besides *L. leucocephala,* were fruit producing tree species that are typically planted in fields or

homes. *L. leucocephala* is a recently introduced agroforestry species that is also typically planted in fields for fodder, or to increase soil fertility.

Within the region of Kaffrine, Bakhoum et al. (2012b) identified *C. glutinosum, Guiera senegalensis*, and *Piliostigma reticulatum* through local perceptions to be increasing and becoming the dominant tree species on the landscape. They confirmed this through a forest inventory, noting that *C. glutinosum, G. senegalensis,* and *P. reticulatum* have high regeneration rates and were the most represented adult species on the landscape. These species were cited as increasing in the present study, but they were also reported as being in decline on the landscape (Table 7.13).

Of these species, two are on the Red List of Endangered Species by the IUCN: *Mangifera indica* and *Psidium guajava*. Both are listed as Data Deficient, meaning that there is an insufficient amount of data on its distribution and/or abundance (IUCN 2018).

Table 7.13 *Tree species listed by the number of respondents that identified them as increasing from 2002-2017, compared with the number of respondents that identified the same species as decreasing.*

		Respondents	
Species	**Common Name (Wolof)**	**Increasing**	**Decreasing**
Cordyla pinnata	Dimb, Dimbu	8	7
Combretum glutinosum	Rat	3	5
Mangifera indica	Mango	3	1
Adansonia digitata	Guy	2	4
Piliostigma reticulatum	Ngiigiis	2	1
Psidium guajava	Guap	2	-
Ziziphus mauritiana	Sidéem	2	-
Anacardium occidentale	Darkase	1	-
Balanites aegyptiaca	Sump	1	3
Carica papaya	Papikaya	1	-
Citrus spp.	Limon	1	-
Eucalyptus camaldulensis	Kotyl-buteel	1	-
Faidherbia albida	Kàdd	1	3
Guiera senegalensis	Nger	1	3
Heeria insignis	Waswasor	1	3
Lannea acida	Son	1	8
Leucaena leucocephala	Leucaena	1	-
Manilkara zapota	Sàppóoti	1	-
Musa spp.	Banana	1	-
Vachellia seyal	Fonax (green), Surur (red)	1	1

7.1.2 Causation and Continuation of Forest Change

7.1.2.1 Causation of Forest Change

7.1.2.1.1 Decreasing Forests

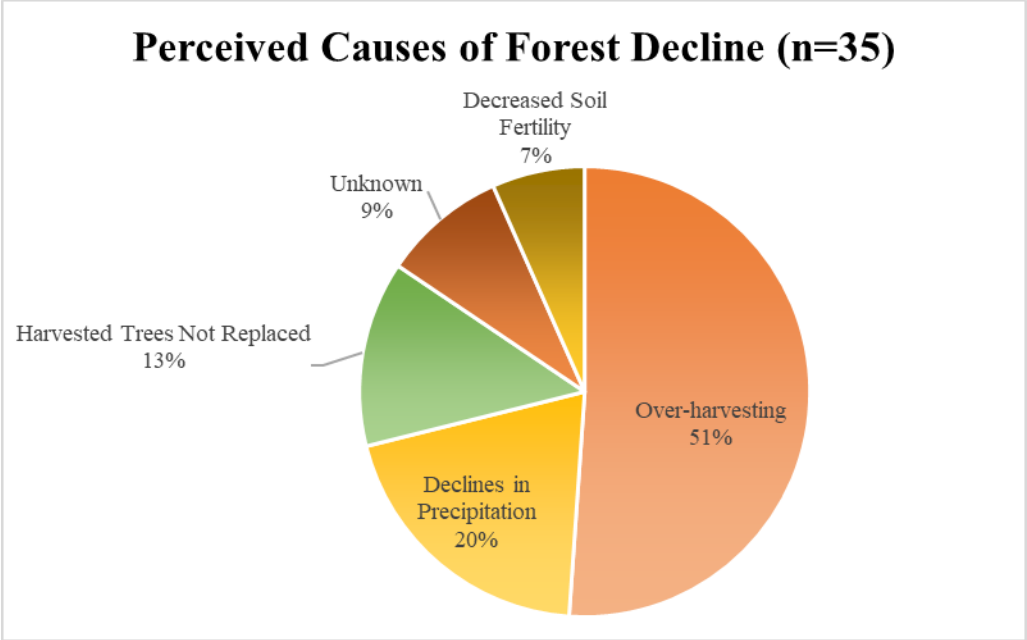

Figure 7.1 *Local respondents' perceived causes of forest decline in the region of Kaffrine.*

Of the 50 total respondents in the region of Kaffrine, 35 (70%) stated that from 2002-2017 the amount of woody cover on the landscape has decreased. Among those 35 individuals, the majority believed that the decline in woody cover was due to the over-harvesting of trees and tree products such as roots, leaves, and fruit (Figure 7.1). The second most commonly stated reason, at 20%, was declines in precipitation.

> *"Why do I think this? Because there has been lots of damage. There is no forest on the landscape. The trees give only, and people cut them down as if they do not have importance. That is the reason that the trees are decreasing…"*

> *"We have cut the trees in the forest. We cut them for fuelwood to cook with. We have watched many trees be cut and taken away on carts to be sold. We collect trees and branches for making fencing. We collect fuelwood to cook bread. Those are the reasons that the trees are decreasing. When you cut the trees, they do not come back."*

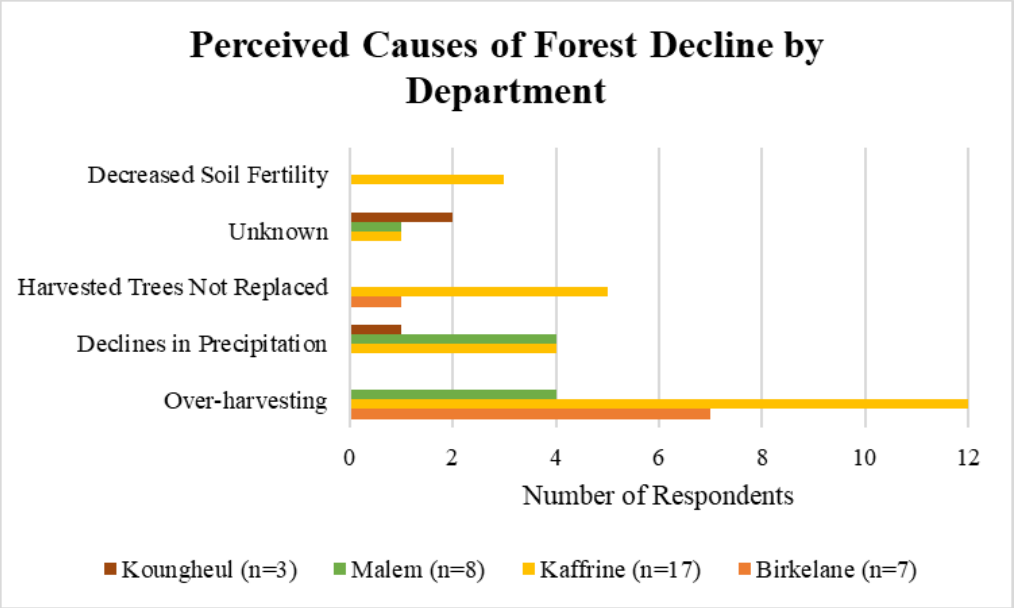

Figure 7.2 *The perceived causes of forest decline from 2002-2017, reported by department.*

Within the department of Birkelane, there was a strong perception (87.5%) that the reason for the perceived decline in woody cover was due to over-harvesting trees and forest products (Figure 7.2). The majority of respondents in the department of Kaffrine also suggested over-harvesting as the main cause of woody cover decline (48%). In the department of Malem, over-harvesting and declines in precipitation were equally reported (44.4%) as the main causes of woody cover decline. Of the individuals in the department of Koungheul who reported a perceived decline in woody cover (n=3), two of them stated that they did not know why the decline had occurred, and one stated that the decline in woody cover was due to declines in precipitation.

7.1.2.1.2 Increasing Forests

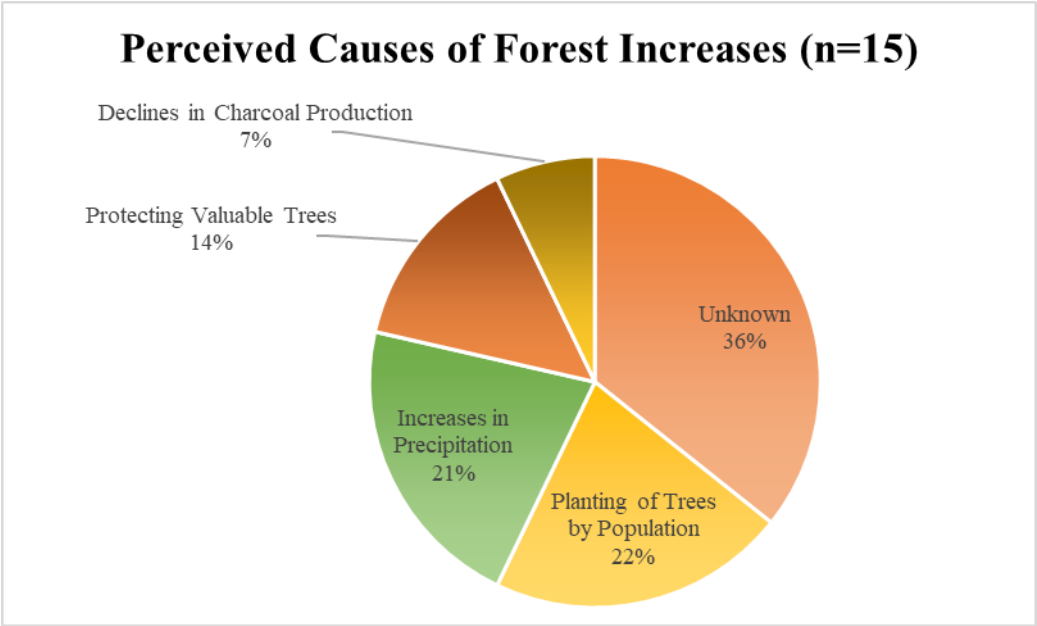

Figure 7.3 *Local population respondents' perceived causes of forest increases in the region of Kaffrine.*

Fifteen individuals across the region stated that they perceived woody cover to have increased from 2002-2017. The most commonly stated reason for this perceived increase was unknown (35.7%), followed by the local population having planted trees (21.4%) and increases in precipitation (21.4%) (Figure 7.3). The other stated reasons for this perceived increase in woody cover included people protecting trees due to their value to the local populations and a decline in charcoal production. A respondent from the department of Kaffrine stated that,

> *"People are planting trees. If you are planting trees, then they are going to increase. Many people are planting trees, this person is planting, this person is planting, and this person is planting. You know that the forest is increasing because people are planting trees."*

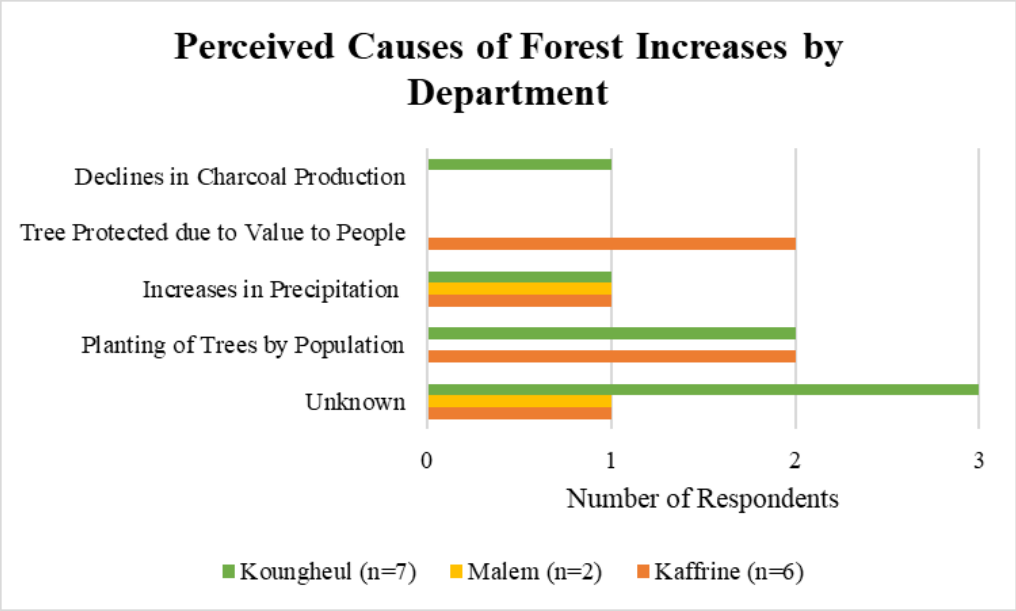

Figure 7.4 *Local respondents' perceived causes of forest increases by department.*

As shown in Figure 7.4, two individuals in the department of Malem reported a perception of forest increases. One cited an increase in precipitation as the reason for the increase. The other stated that they did not know why the increase had occurred. Within the Department of Kaffrine, six individuals reported a perception of forest increases. Approximately two-thirds of these individuals believed the increase to be due to local populations that were planting trees and protecting trees that they felt were valuable. Seven individuals in the department of Koungheul perceived forests to be increasing, and close to half of them stated that they did not know why the increase had occurred.

7.1.2.2 Continuation of Forest Change

7.1.2.2.1 Continuation of Forest Decline

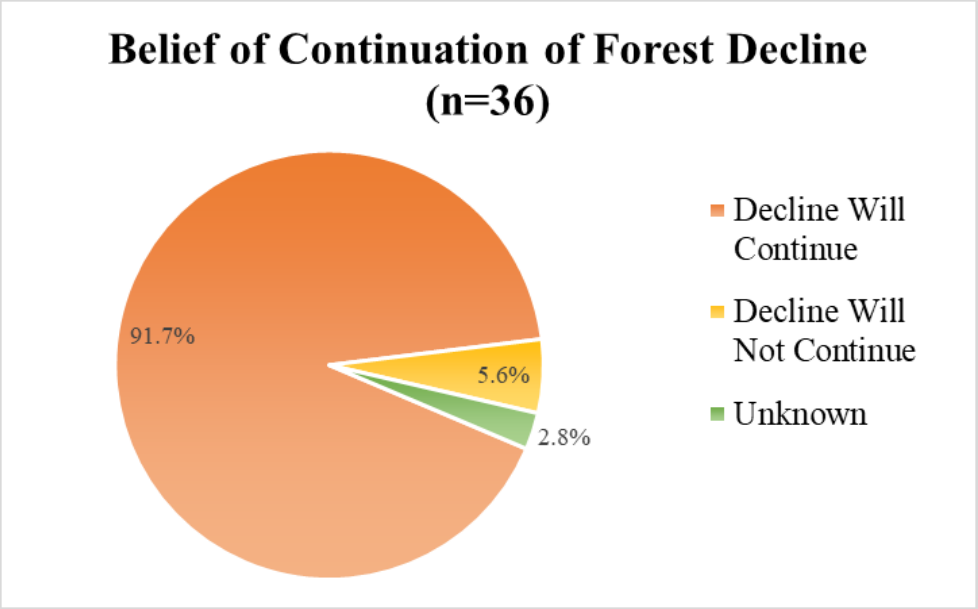

Figure 7.5 *Percent of local respondents within the region of Kaffrine regarding the continuation of forest decline.*

Within the region of Kaffrine, individuals who reported a perception of forest decline overwhelming stated that they believed forests would continue to decline in the future (Figure 7.5). Additionally, one individual in the department of Kaffrine who had stated that forests had increased from 2002-2017 reported that they believed forests would decline in the future.

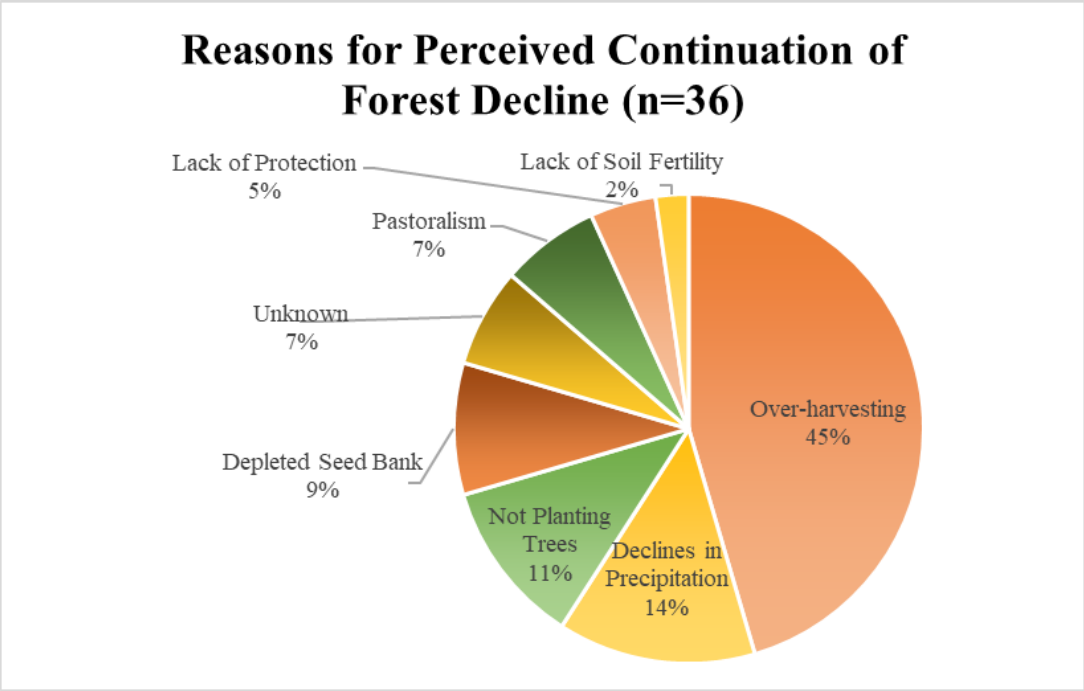

Figure 7.6 *Reasons that local respondents within the region of Kaffrine reported that they believed forests would continue to decline in the future.*

Throughout the region of Kaffrine (n=36), the prevailing belief was that declines in woody cover will continue to occur due to the over-harvesting of forest products (45.5%). This was followed by declines in precipitation (13.6%) and not planting trees (11.4%) (Figure 7.6). These results suggest that the same activities that respondents' perceived to have caused forest decline in the past (over-harvesting; declines in precipitation; not replacing harvested trees (Figure 7.1)) are expected to continue to take place into the future.

These trends were consistent across the departments of Kaffrine and Birkelane (Figure 7.7). In the department of Malem, over-harvesting, a depleted seed bank, and declines in precipitation were reported at equal frequencies (30%) as reasons for the belief of a continued decline in woody cover. Within the department of Koungheul, over-harvesting, declines in precipitation, and did not know were all reported at equal frequencies (33.3%).

> *"I know that we are damaging them [trees], and making them decrease. We take them for our needs, and our needs are increasing. That is the reason that I think the decrease has happened. If we were to give back what we took, there would be many trees, but we only damage the trees, and the forest."*

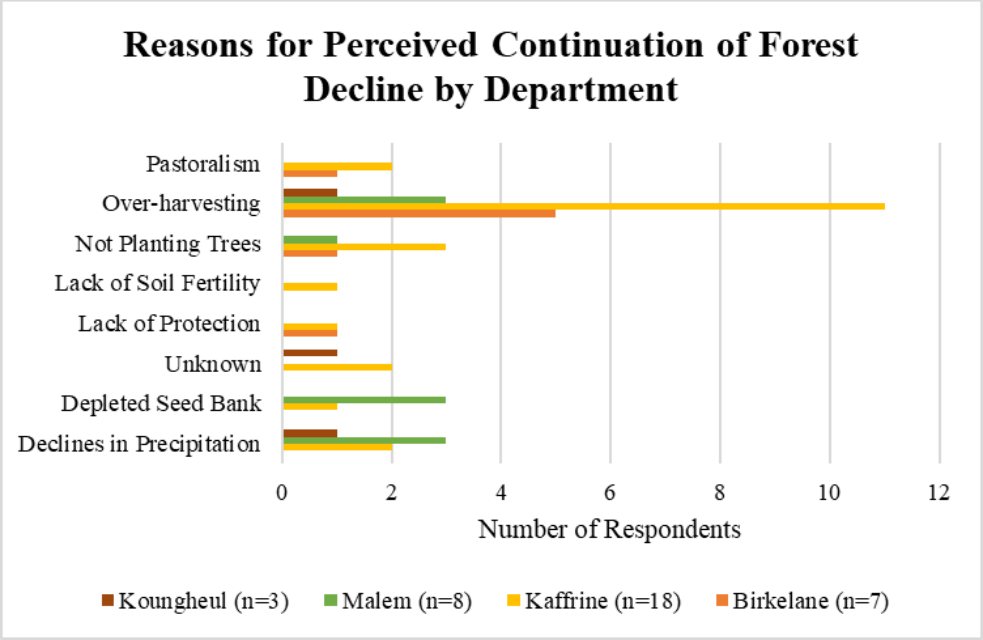

Figure 7.7 *Reasons that local respondents within the region of Kaffrine, delineated by department, reported that they believed woody cover would continue to decline in the future.*

7.1.2.2.2 Continuation of Forest Increases

Of the respondents who reported a perceived increase in woody cover throughout the region (n=15), 93% of them stated that they believed the increase in woody cover would continue into the future, with one respondent in the department of Kaffrine stating that they believed that forests would begin to decline in the future.

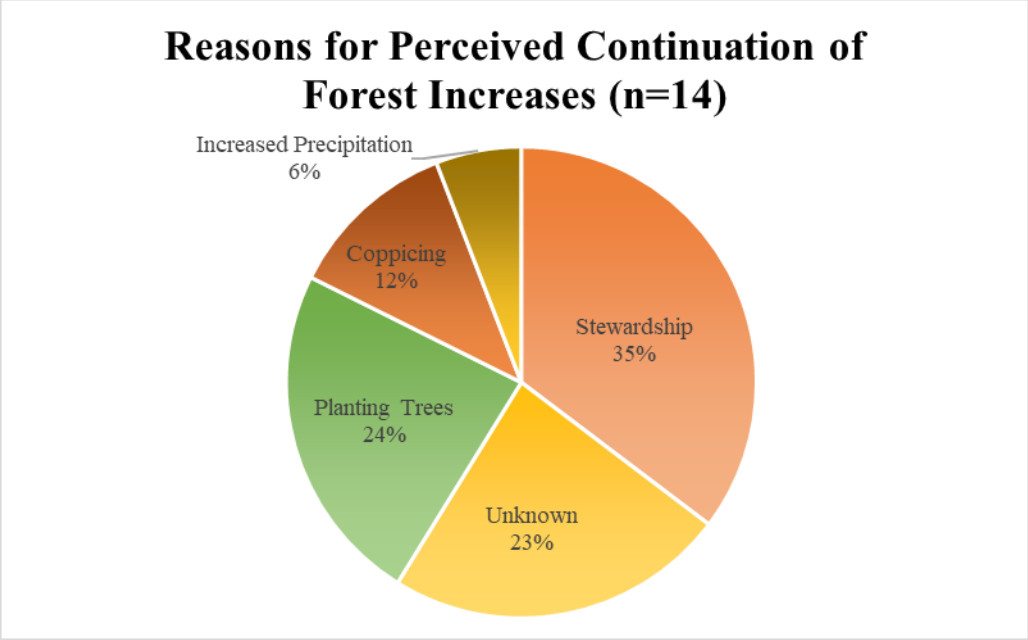

Figure 7.8 *Reasons that local respondents within the region of Kaffrine reported that they believed woody cover would continue to increase in the future.*

The preeminent stated reason that the increase in woody cover would continue to occur in the future was due to stewardship, or protection, of the forest (35.3%) (Figure 7.8). Almost a quarter of respondents stated that they did not know why the increase in woody cover would continue into the future. Another quarter reported that woody cover would continue to increase due to people planting trees.

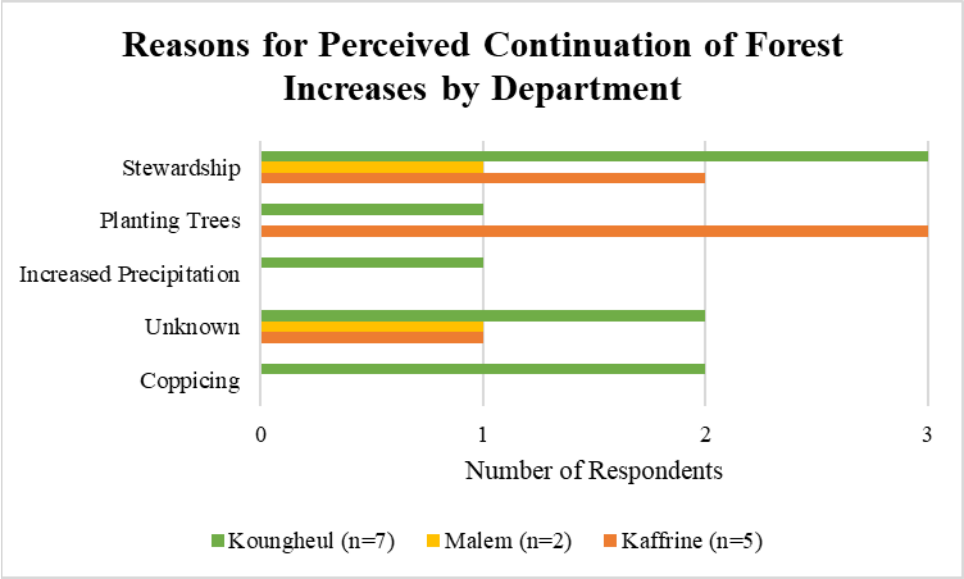

Figure 7.9 *Reasons that local respondents within the region of Kaffrine, delineated by department, reported that they believed woody cover would continue to increase in the future.*

Reasons for the continuation of the increase in woody cover were most variable in the department of Koungheul, with the strongest reported reason having been stewardship, followed by coppicing, and not knowing why, as well as planting trees and increased precipitation (Figure 7.9). In the department of Kaffrine, there was a strong belief that the increase would continue due to people planting trees, followed by stewardship. Perceived reasons for the continuation of increases in woody cover were split between stewardship and not knowing why in the department of Malem.

7.1.3 Effects of Forest Change on Community

7.1.3.1 Community Discussion

Across the region (n=47), a large majority of respondents (89.4%) reported that they and their communities had discussed the forest changes that have taken place. The remaining 10.6% of respondents reported they had not discussed the changes that had occurred with their communities.

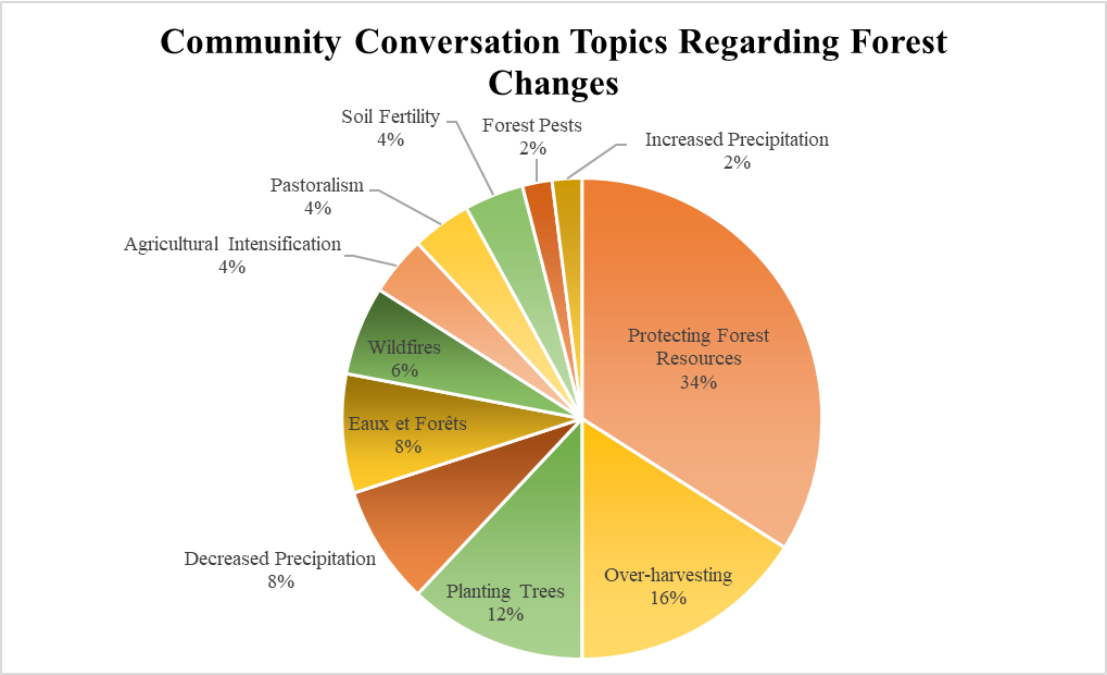

Figure 7.10 *Reported topics within the region of Kaffrine that have been discussed by communities regarding forest change.*

A range of topics had been discussed by communities concerning forests changes (Figure 7.10). The most commonly discussed topics were protecting forest resources (34%), over-harvesting (16%), and planting trees (12%).

7.1.3.2 Difficulty of Obtaining Forest Products

The majority of respondents (87.5%) throughout the region of Kaffrine (n=47) stated that they experienced difficulties obtaining forest products for daily activities such as cooking, construction, and the practice of traditional medicine. This response was consistent across the four departments (Figure 7.11).

> "*Yes, I have difficulties with this. I do not see the trees that I need. They are no longer here. They have them in the Casamance. People bring them here, to the weekly markets, and sell them. I am able to buy them there. They are no longer found in the forest here.*"

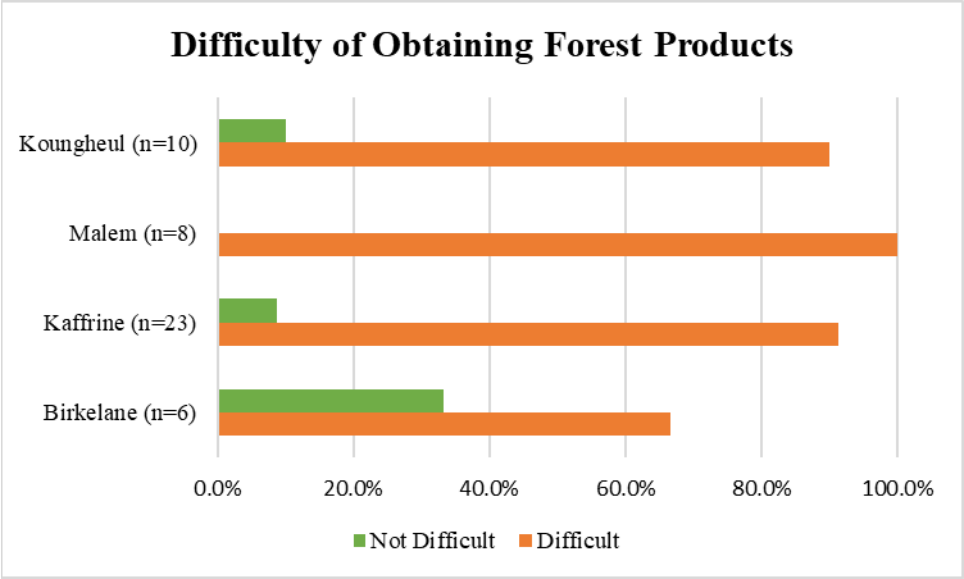

Figure 7.11 *The perceived difficulty of obtaining forest products by local respondents, delineated by department.*

The majority of respondents (83.7%) throughout the region of Kaffrine (n=48) stated that they had to travel a long distance to obtain forest products that they used for daily activities. This trend was also consistent at the departmental scale (Figure 7.12).

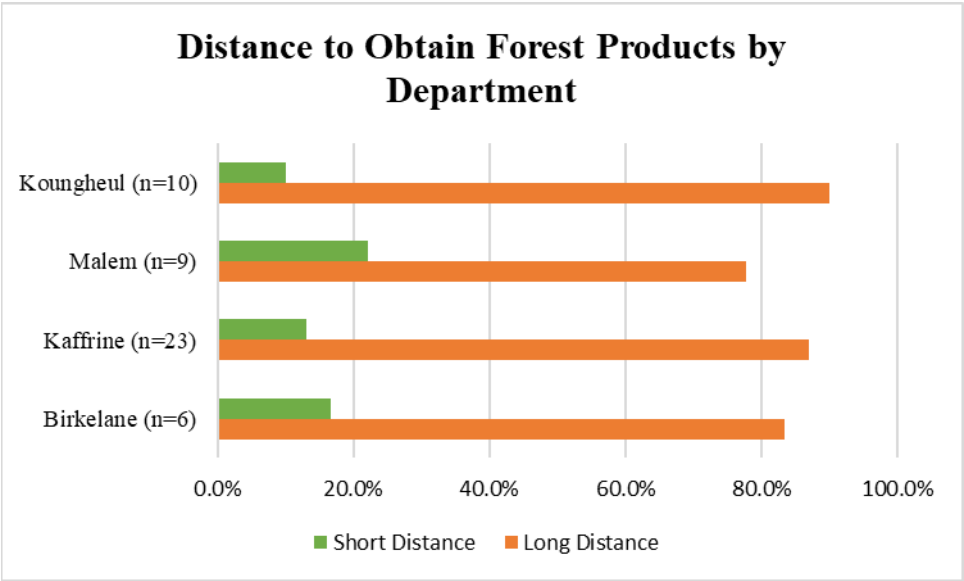

Figure 7.12 *Local respondents' perceived distance needed to travel in order to obtain needed forest products, delineated by department.*

Twenty-nine respondents throughout the region reported perceived distances needed to travel in order to collect needed forest products (Table 7.14). The greatest distance was reported within the department of Kaffrine, followed by the department of Malem.

Table 7.14 *Local respondents' perceptions of distance needed to travel to collect forest products in 2017.*

Location	Distance (km)	
Department	**Average**	**Range**
Birkelane (5)	2.8	1-5
Kaffrine (13)	9.7	2.5-30
Malem (6)	7.2	3-20
Koungheul (7)	5	1.5-9.5
Region (29)	7	1-30

7.1.3.3 Utilization of Forest Products

Local respondents were asked how they utilized trees in their daily lives. Of the fifty local respondents interviewed, 44 referenced ways that they utilize trees. The most commonly referenced use of trees was as a source of food, followed by traditional medicine, and fuelwood (Table 7.15). There were no detectable differences amongst departments in these answers. The reported utilization of tree species between genders did not differ substantially, except men predominantly referenced the utilization of tree species in traditional medicine, congruent with Wolof gender roles.

Table 7.15 *Utilization of trees and forest products referenced by respondents.*

Utilization	Respondents	References
Food	29	160
Traditional Medicine	15	78
Fuelwood	14	59
Wood Products	10	33
Fencing	6	20
Live Fencing	4	16
Soil Fertility	3	13
Fodder	1	3
Soap	1	2
Charcoal	1	1

The three tree species that were most commonly referenced as being utilized by local respondents were *C. pinnata*, *M. indica*, and *C. glutinosum* at 34, 22, and 16 references, respectively. A table with all tree species referenced as being utilized by local respondents is located in Appendix F.1, and a table with tree species referenced with their associated utilization is located in Appendix F.2. All of the tree species most commonly identified as decreasing or having disappeared from the landscape (Table 7.11) were also identified as trees that were utilized by local respondents. These tree species, along with

introduced species utilized for food production and agroforestry practices, were the species that were most commonly referenced as being utilized by local communities.

7.1.3.4 Perception of Forest Changes

In the region of Kaffrine, those who had reported a perception of woody cover decline (n=35) all stated that the changes that had occurred in the environment had been non-beneficial. Of those who reported a perception of increases in woody cover (n=15), 92.8% stated that the changes had been beneficial, and 7.2% stated that the increase had been non-beneficial. This was consistent across departments, with most respondents having perceived a decline in woody cover and having perceived that decline to be a non-beneficial change. A majority of respondents in the department of Koungheul had reported a perception of increases in woody cover, with a majority also reporting that these changes were beneficial (Figure 7.13).

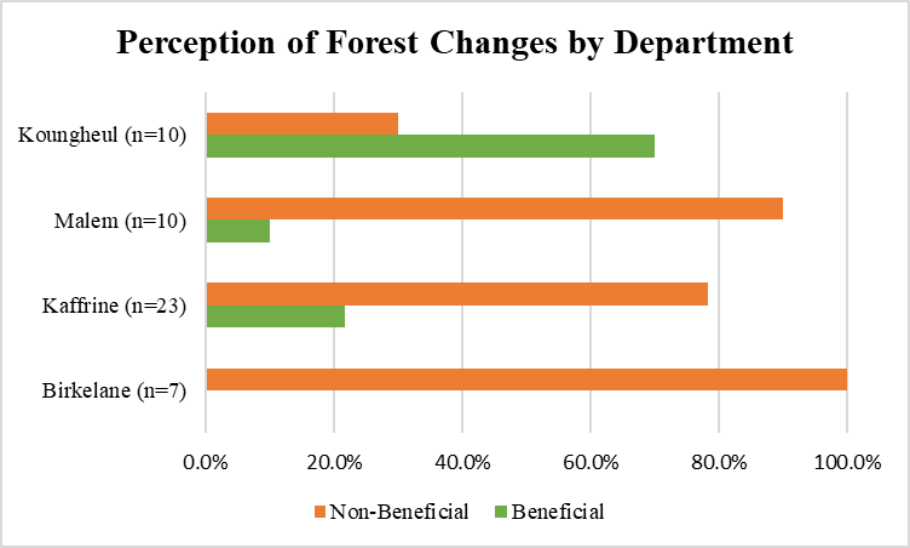

Figure 7.13 *Local respondents stated belief regarding if forest changes have been beneficial or non-beneficial, delineated by department.*

When asked why the forest changes were perceived to be non-beneficial, the two most common answers were decreased food security and increased water scarcity (Figure 7.14). These were followed by decreased access to traditional medicine and decreased financial security. The references to decreased food security and access to traditional medicine as non-beneficial impacts of decreased woody cover are congruent with local respondents stating that tree species are often utilized as sources of food and traditional medicine.

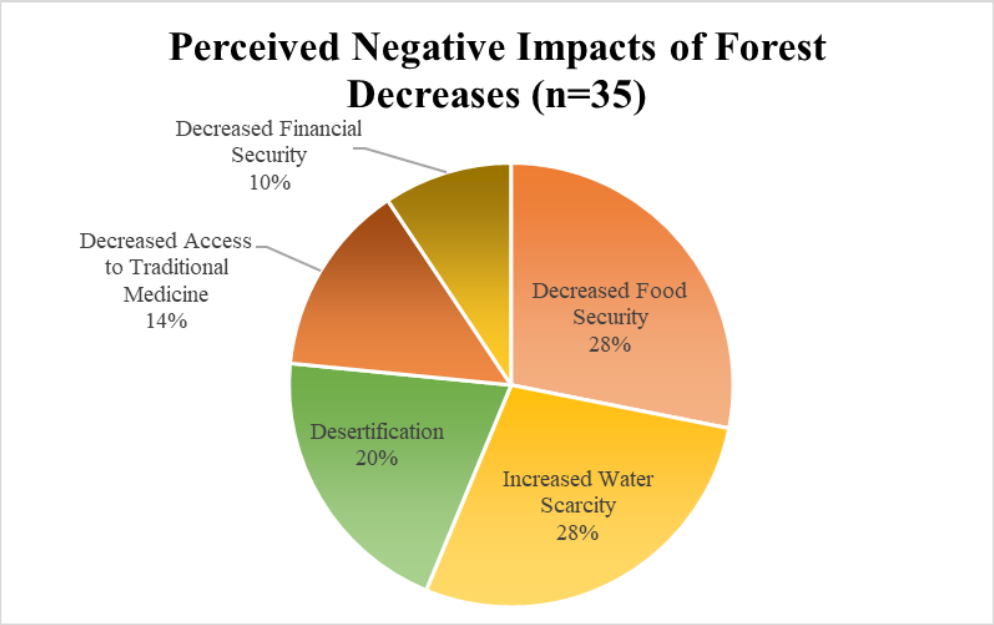

Figure 7.14 *Local respondents' perceived negative impacts that are experienced, or exacerbated, due to perceived forest decreases.*

Interestingly, respondents who reported increases in woody cover (n=15) described perceived benefits that closely mirrored the perceived negative impacts described by respondents that reported decreases in woody cover (n=35). The most commonly reported perceived benefit was increased food security followed by improved environmental conditions, increased financial security, increased water security, and access to traditional medicine (Figure 7.15).

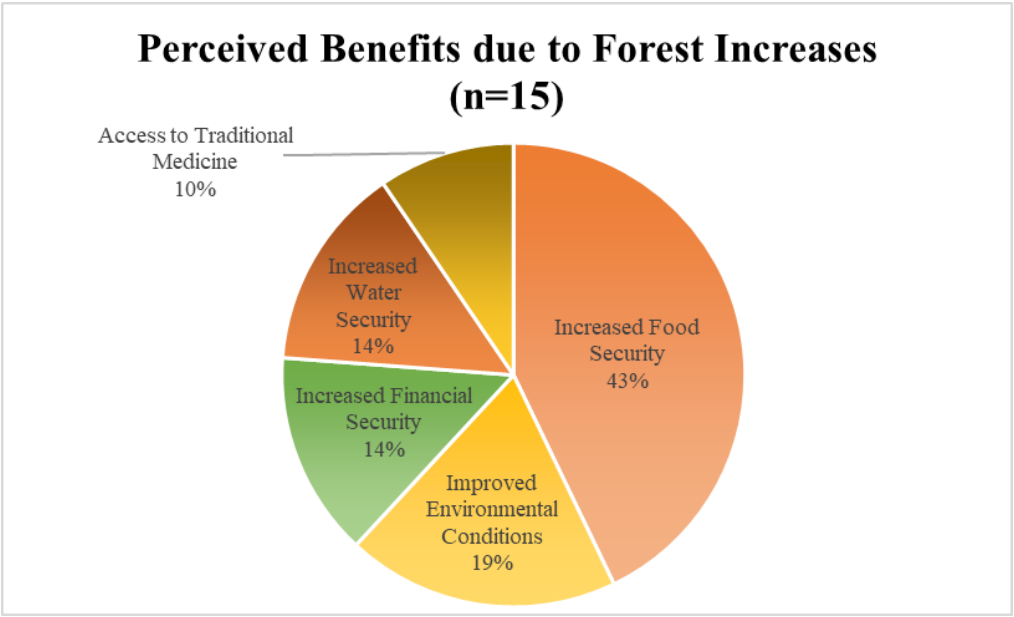

Figure 7.15 *Local respondents' perceived benefits that are experienced, or improved, due to perceived forest increases.*

This demonstrates that whether members of the local population perceive woody cover to have increased or declined, they all identify the same ecological goods and services as being affected by the amount of woody cover on the environment: food security; environmental health; water security; financial security; and access to traditional medicine.

7.1.3.5 Group that will be Most Affected by Forest Changes

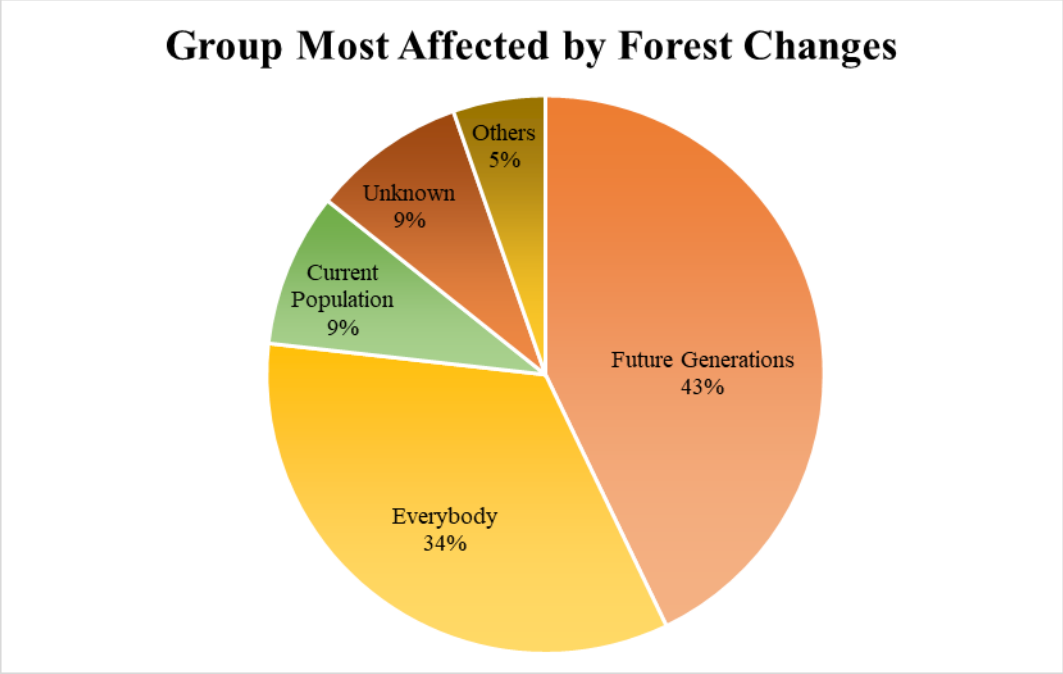

Figure 7.16 *Groups that local respondents throughout the region of Kaffrine perceive as being the most affected by forest changes.*

A large portion of respondents (n=50) felt that future generations would be the most impacted by forest changes that have occurred within the region of Kaffrine. This was followed by the belief that everyone (33.9%) would be most affected by the changes that have occurred (Figure 7.16).

> *"It has started to be difficult for us, and it will be more difficult for the children in the future."*

> *"The coming generations, they will have problems. Today, the young children, if you ask them, "What is loro (Ficus iteophylla)?" They will say, "I do not know." They will have problems."*

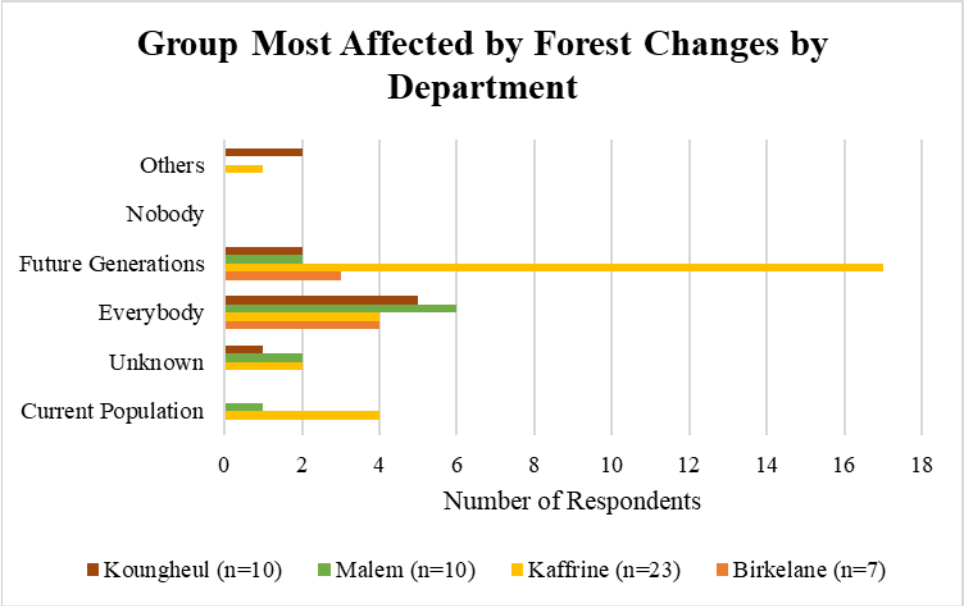

Figure 7.17 *Groups that local respondents perceive as being the most affected by forest changes, delineated by department.*

This trend was not consistent across departments. The majority of respondents in the department of Kaffrine felt that future generations would be most affected by forest changes, but respondents within the remaining departments most commonly responded that everyone would be most affected by forest changes (Figure 7.17). This suggests that respondents in the department of Kaffrine believe that conditions will become worse in the future, while respondents from the remaining departments believe that they and others are being affected just as much as future generations will be. This belief implies that they either do not perceive that the impacts of forest changes will worsen in the future or they feel that future generations will not be as reliant on the forest as the population is currently.

7.1.4 Action

7.1.4.1 Actions to Prevent Forest Loss

When respondents (n=49) were asked if they had taken action to prevent forest loss, close to two-thirds (63.3%) responded that they had not. This trend was more prominent amongst women than men throughout the region, with 75% of women stating that they had not taken action to prevent forest loss versus only 55% of men stating that they had not done so (Figure 7.18).

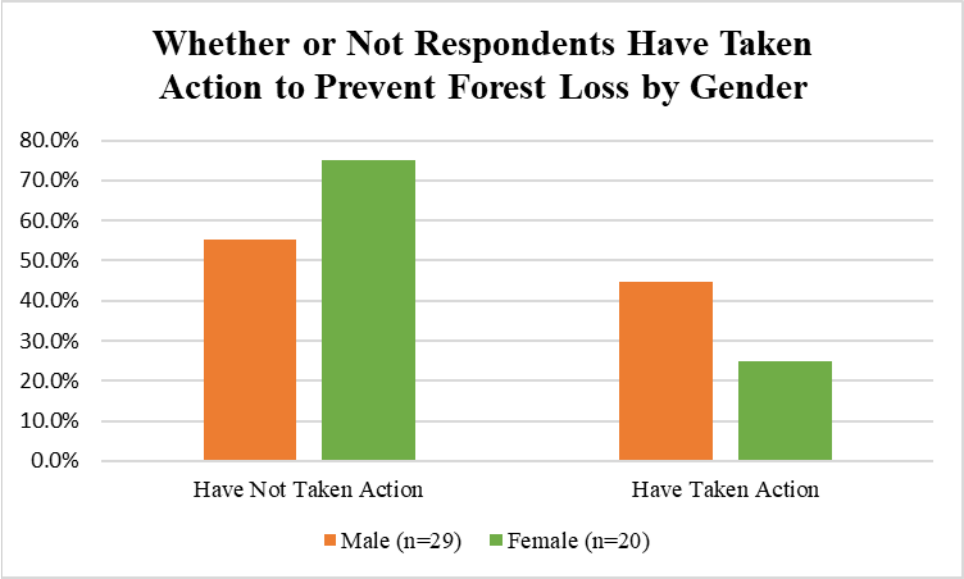

Figure 7.18 *Local respondents throughout the region of Kaffrine that reported having, or not having, taken action to prevent forest loss, delineated by gender.*

Responses were variable across departments, with all respondents in the department of Malem stating that they had not taken action to prevent forest loss and 67% of respondents in the department of Koungheul reporting that they had taken action to prevent forest loss (Figure 7.19). This is consistent with previous responses within the Koungheul department with close to half of respondents reporting a perception of increasing woody cover being due to people planting trees and declines in charcoal production.

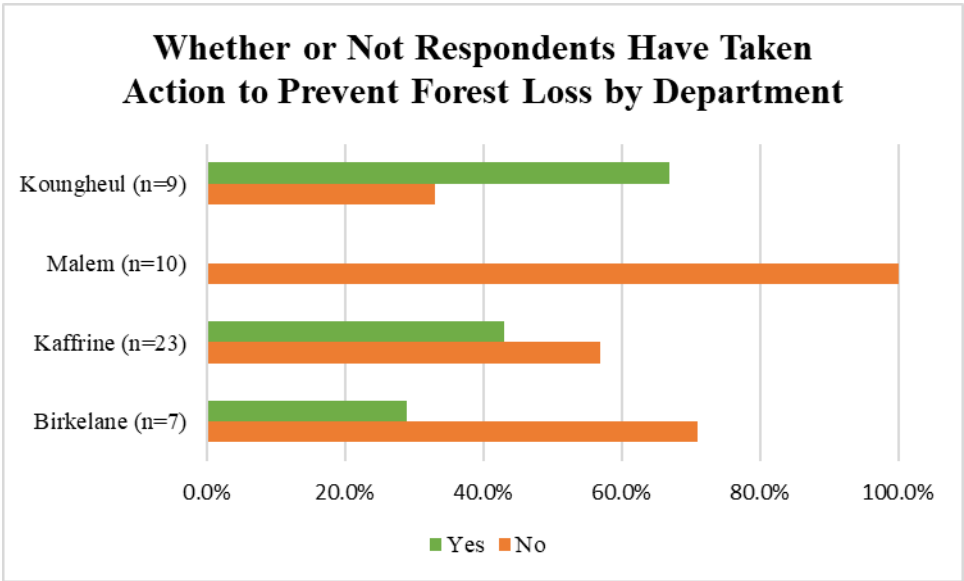

Figure 7.19 *Local respondents throughout the region of Kaffrine that reported having, or not having, taken action to prevent forest loss, delineated by department.*

7.1.4.1.1 No Action Taken to Prevent Forest Loss

Of the approximately two-thirds of respondents who stated they had not taken action to prevent forest loss, 22 of them gave a reason why. Of those 22, half of them reported that they had not done so because they were unable to (Figure 7.20). Approximately another quarter of respondents reported that they had not taken action against forest loss because they did not know how to do so. The remainder reported that they had not yet taken action or that they had not taken action because Allah (God) would do so.

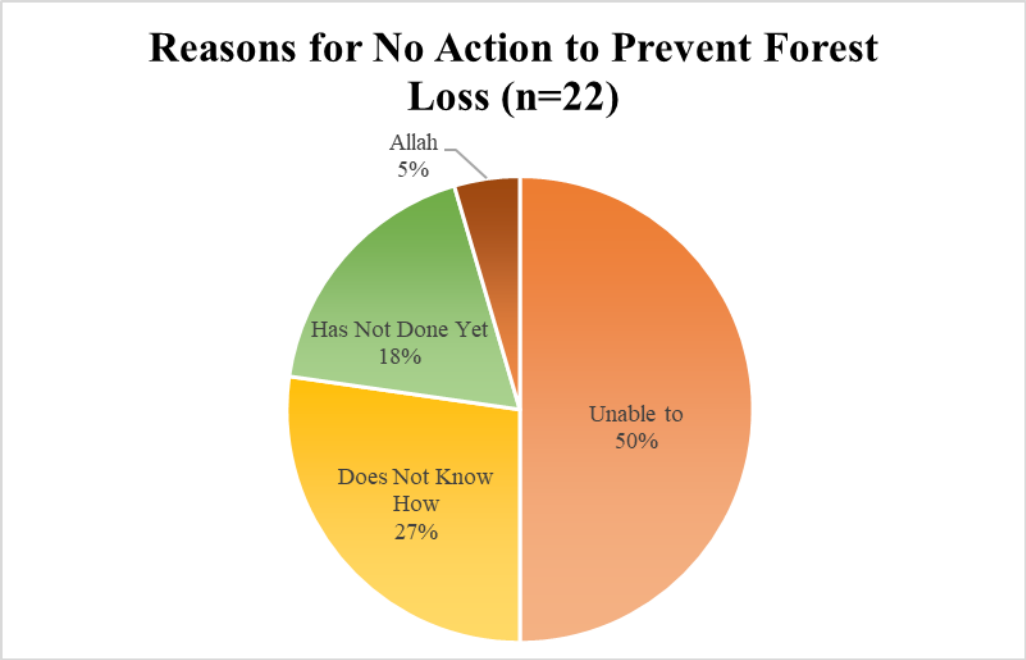

Figure 7.20 *Stated reasons of local respondents throughout the region of Kaffrine for having not taken action to prevent forest loss.*

Reported reasons for having not taken action to prevent forest loss varied by department (Figure 7.21). The two individuals within the department of Birkelane who reported reasons for having not taken action against forest loss both stated that they had not done so because they were unable to do so. This was also the majority perception in the departments of Malem and Kaffrine. Both individuals who provided reasons in the department of Koungheul stated they had not taken action because they did not know how to do so.

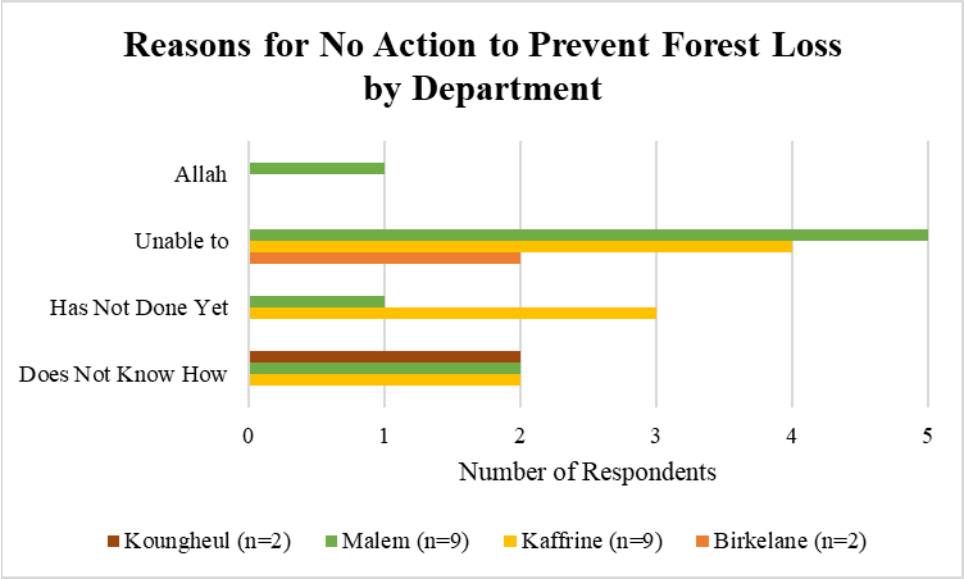

Figure 7.21 *Stated reasons of local respondents throughout the region of Kaffrine for having not taken action to prevent forest loss, delineated by department.*

Interestingly, the majority of men (58.3%) stated that the reason they had not taken action to prevent forest loss was that they were unable to do so (Figure 7.22). Women mainly responded that they had not taken action to prevent forest loss because they did not know how (40%) or they were unable to do so (40%).

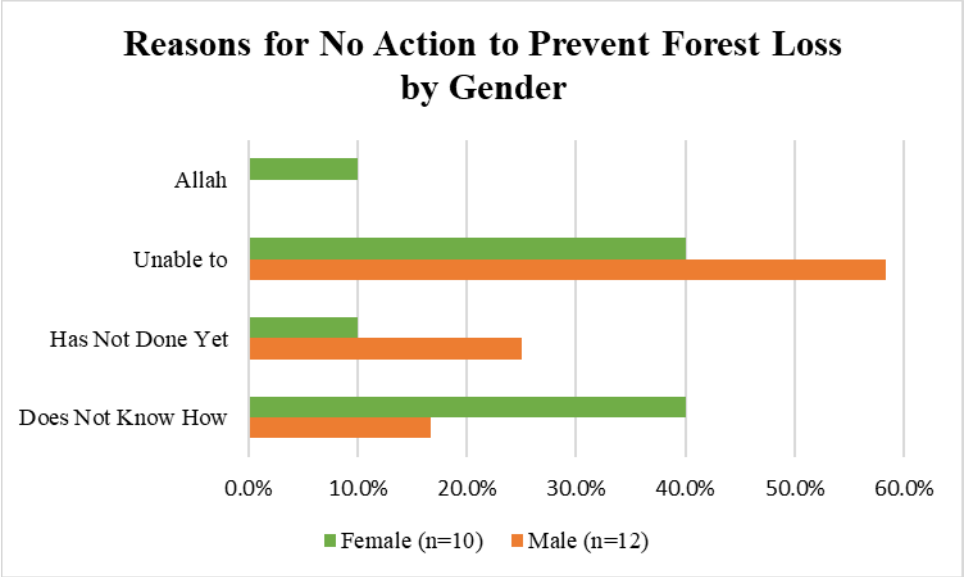

Figure 7.22 *Stated reasons of local respondents throughout the region of Kaffrine for having not taken action to prevent forest loss, delineated by gender.*

7.1.4.1.2 Action Taken to Prevent Forest Loss

Of the 18 individuals throughout the region who reported they had taken action to prevent forest loss, all of them described actions that they had done to do so. The two most commonly reported activities were planting trees and raising community awareness (Figure 7.23).

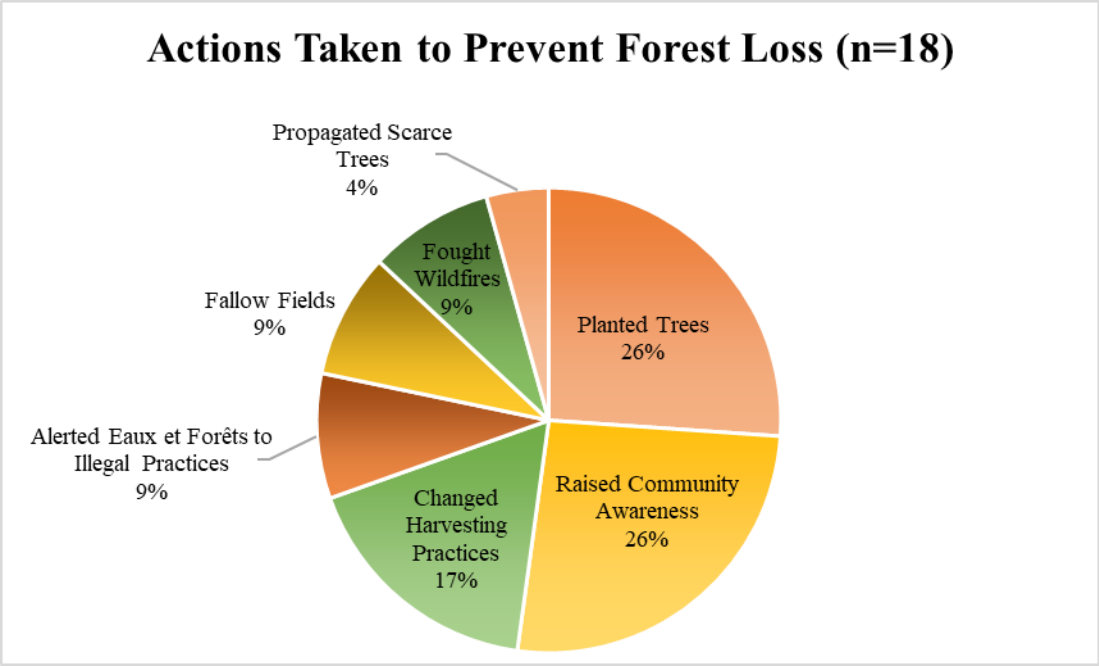

Figure 7.23 *Reported actions taken by local respondents to prevent forest loss in the region of Kaffrine.*

No respondents from the department of Malem reported having taken action to prevent forest loss. Both of the two individuals in the department of Birkelane who reported taking action against forest loss, reported having done so through raising community awareness (Figure 7.24). Actions taken to prevent forest loss varied across the departments of Koungheul and Kaffrine. Interestingly, no respondents in the department of Koungheul reported planting trees to prevent forest loss, even though two respondents stated that the perceived increase in forests was due to people planting trees and one respondent stated the increase in forests would continue into the future due to people planting trees.

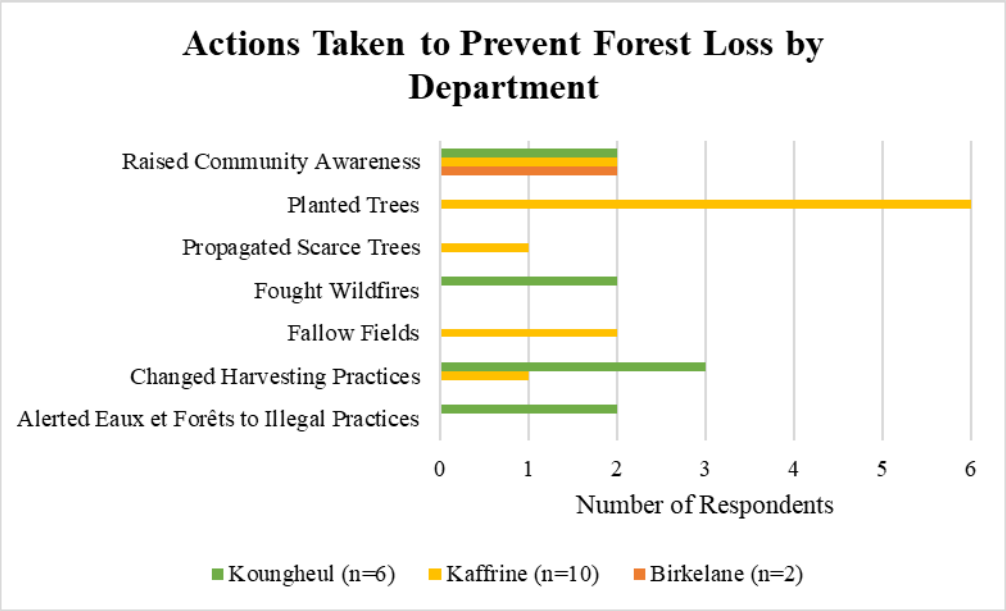

Figure 7.24 *Reported actions taken by local respondents to prevent forest loss in the region of Kaffrine, delineated by department.*

When comparing actions to prevent forest loss by gender, male respondents reported a more diverse range of actions (Figure 7.25). The two most commonly reported actions by male respondents were planting trees (42.9%) and raising community awareness (35.7%). No women reported planting trees in order to help prevent forest loss. Instead, women reported taking action by allowing fields to go fallow (40%), changing harvesting practices (40%), and raising community awareness (20%).

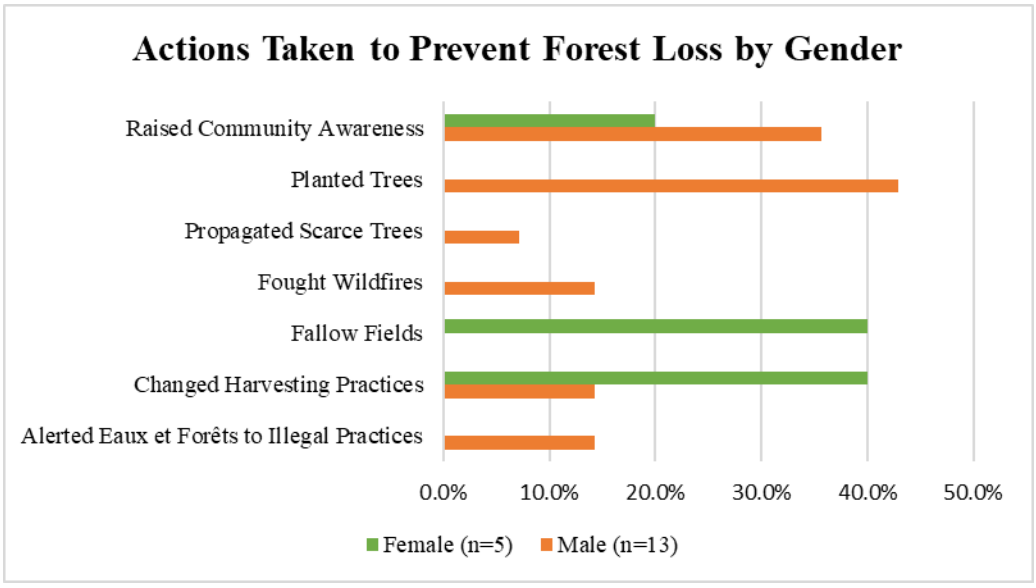

Figure 7.25 *Reported actions taken by local respondents to prevent forest loss in the region of Kaffrine, delineated by gender.*

7.1.4.2 Tree Planting

Throughout the region (n=50), 90% of the 50 interviewees reported having planted trees; only 10% of respondents stated that they had never planted trees.

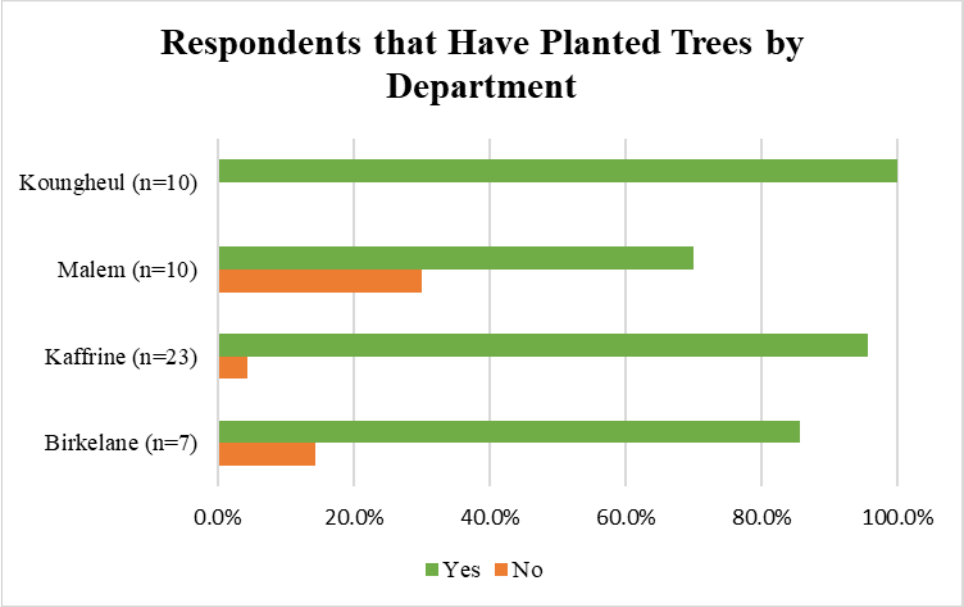

Figure 7.26 *Local respondents throughout the region of Kaffrine that reported having planted trees, delineated by department.*

All the respondents in the department of Koungheul reported having planted trees (Figure 7.26). The department of Malem had the highest percentage (30%) of individuals that reported having not planted trees.

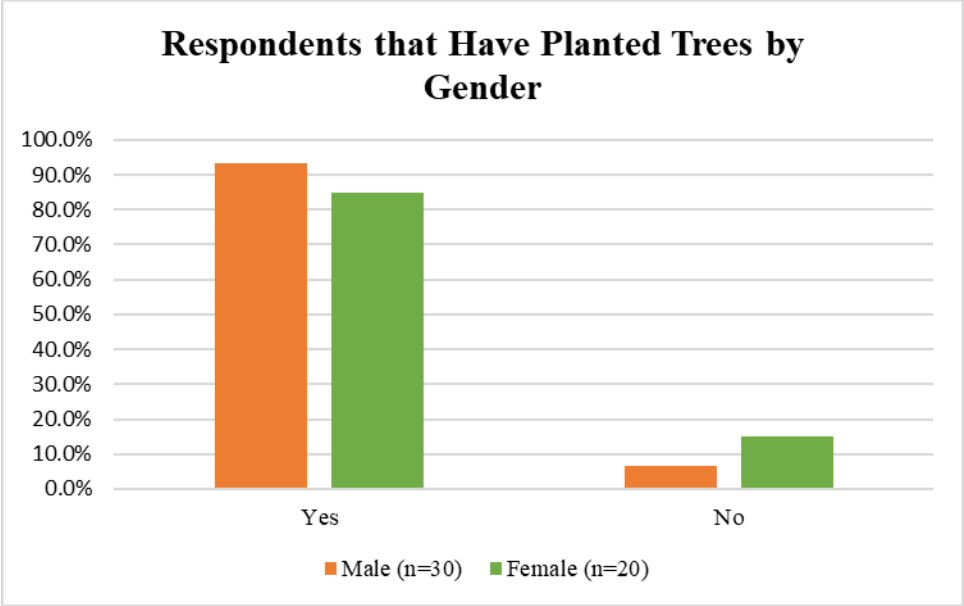

Figure 7.27 *Local respondents throughout the region of Kaffrine that reported having planted trees, delineated by gender.*

A higher proportion of men (93.3%) than women (85%) reported having planted trees (Figure 7.27), although this difference was not pronounced.

Table 7.16 *Top ten most commonly reported planted tree species, arranged by number of references. "Respondents" is number of respondents that referenced the species as planted, and "References" is the total number of times a species was referenced as planted.*

Species	Common Name (Wolof)	Respondents	References
Mangifera indica	Mango	37	41
Anacardium occidentale	Darkase	19	22
Psidium guajava	Guap	18	21
Eucalyptus camaldulensis	Kotyl-buteel	14	14
Carica papaya	Papikaya	12	13
Citrus spp.	Limon	11	12
Vachellia nilotica	Neb Neb	10	12
Ziziphus mauritiana	Sidéem	7	8
Leucaena leucocephala	Leucaena	6	10
Cordyla pinnata	Dimb, Dimbu	5	5

Of the 45 individuals that reported having planted trees, they cited 43 separate tree species 224 times. The most commonly reported planted tree species was *M. indica* (Table 7.16). *M. indica* is a valuable food and income source; therefore, it is unsurprising that this introduced species was the most frequently reported planted tree species. *M. indica* was followed in references by *Anacardium occidentale* and *Psidium guajava*. These two species are also introduced fruit producing species that are considered valuable food and income sources. Of the top ten most frequently referenced planted tree species, only three are native to Senegal: *Vachellia nilotica, Ziziphus mauritiana,* and *C. pinnata.*

Additionally, Peace Corps and Trees for the Future (a Non-governmental organization (NGO) with a nearby demonstration farm/extension outpost) extend all of these tree species, besides *M. indica*. A full list of tree species that were reported as having been planted by respondents is located in Appendix G.

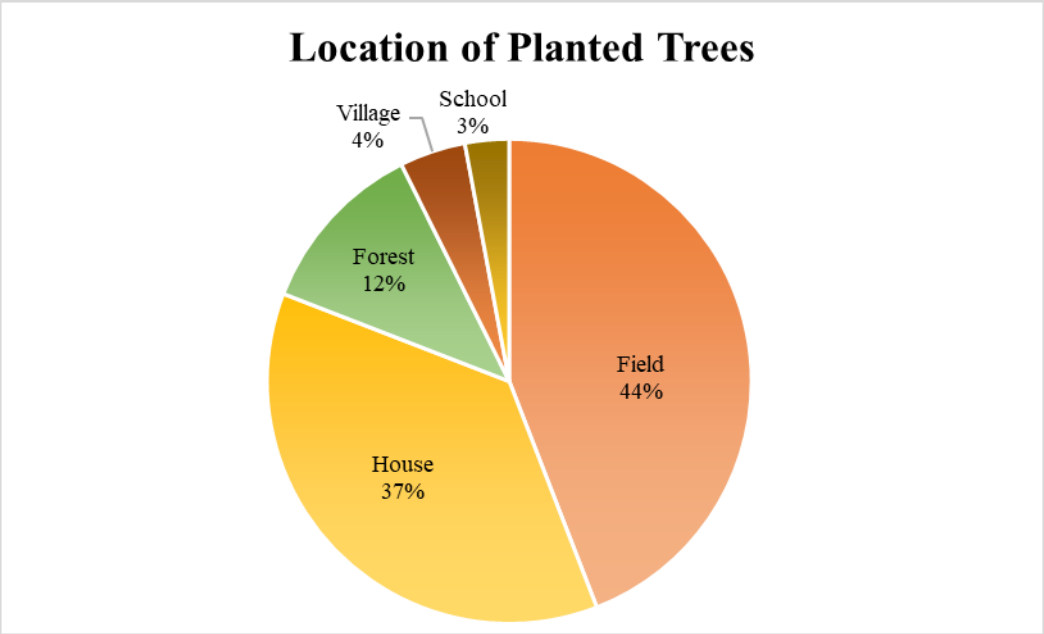

Figure 7.28 *Reported tree planting locations by local respondents within the region of Kaffrine.*

Of the 45 individuals that reported having planted trees, 43 of them provided locations where they had planted trees. The two most commonly cited locations for planting trees were within people's fields (44%) and at their houses (37%) (Figure 7.28). Only eight respondents (11.8%) reported having planted trees in the forest. This is greater than the amount of respondents (6) who stated that they had planted trees as a way of taking action against forest loss. Many respondents reported that they had not planted trees in the forest as they felt that there was no way to protect trees from livestock when they are planted in the forest.

> *"I am unable to plant trees in the forest. The forest does not have protection. Sheep are able to eat them there. There is no protection."*

> *"I have planted trees in my field only. There is not protection in the forest. If you plant them there, they will get damaged."*

7.2 Key Informants

All of the key informants reported decreases in forested areas within their jurisdictions for the period of 1987-2017 and 2002-2017, which they believed were primarily caused by anthropogenic factors and secondarily due to climatic variability. They all reported a

lack of resources to be able to deal with these changes. A strong emphasis on working with local communities, mainly through local collectives, was expressed by each of the key informants.

As there were only four key informants, their responses were treated qualitatively, rather than quantitatively as the responses of members of the local population were treated.

7.2.1 Roles of Office

7.2.1.1 Tracking Forest Changes

While each of the four departments reported tracking forest changes through various means, their stated methods are not sufficient for providing accurate and timely data regarding forests changes in their jurisdictions or throughout the region.

Key informants stated that the Centre de Suivi Écologique (CSÉ) conducts a national forest inventory every 15 years, using remotely sensed imagery. The last time a national inventory was conducted was 2002. I was unable to locate this report. The CSÉ was created in 1986 to study desertification and monitor natural resources throughout Senegal (UNOOSA 2017).

In the four departments, key informants reported that visual forest inventories are conducted on an annual basis to determine changes in forested areas. The key informant from the department of Kaffrine stated that,

> *"Ah, to my knowledge, we only observe the forest to monitor changes. For tracking the human population in Senegal, a census is done. This should also be done with the forest, as a photo inventory, that way we know what changes are occurring. That is exactly what needs to be done. Then we would know if it was increasing, if it was decreasing, or if there was a problem."*

The key informant from the department of Birkelane reported that along with visual observations of forest changes, they also annually track wildfires by recording the amount of land area burned, as well as increases in forested area through reforestation and agroforestry efforts.

The department of Koungheul was the only department that specifically mentioned the utilization of members of local communities in monitoring forest changes, stating that they monitor forest changes through information provided by members of local communities to local collectives.

> *"I am able to say that to track forest changes we closely observe the forest. Our tools for being able to track the forest have been cut back. Our tools were able to provide images and information, but we have cut back on them. Now, we are transferring the job of monitoring the environment to local collectives.*

Individuals observe the changes occurring in the forest and then provide this information to the collective, and the collective gives it to Eaux et Forêts. The reason for this is that our strength as an organization is decreasing. Our strength for being able to protect the forests lies with the people. When we increase resources into people, the amount of people going out to monitor the forest increases. The reason that we do this is that Eaux et Forêts is here. We can see the border between the city and the bush, but the forest is further out there. I am able to go there if I have a good working car and gasoline, but I cannot always be out there. I cannot regulate all of the people cutting trees, and therefore the forest is diminishing. For those reasons, we are shifting some responsibilities to the communities and the local collectives."

The department of Malem did not mention utilizing information obtained from members of local communities when monitoring forest changes, but when asked about working with local communities, they did state that local collectives performed forest surveys that were then reported to Eaux et Forêts.

7.2.1.2 Working with Local Communities

All four key informants reported working with local communities within their respective departments, with some similarities and differences in their approaches.

The informant from the department of Birkelane stated that the forests are owned by the local communities and the job of Eaux et Forêts is to help support the local communities in protecting their forests, as well as to propose and enforce regulations for forest management. They stated that,

"..We have transferred skills to the local communities; therefore, the local population is able to protect the forest."

They reported that their main interactions with local communities were through having discussions with individuals who came to the Eaux et Forêts office to obtain information. If information related to forest management needed to be dispersed throughout the department, they would provide the information to the leaders of local collectives who would then disperse the information to members of the local population. They also reported having performed trainings related to agroforestry and natural resource chain management in the surrounding villages.

Within the department of Kaffrine, it was reported that local collectives were in the beginning stages of development and still working to elect governing officials. In lieu of local collectives, they have a program that employs members of local communities to create and manage tree nurseries. Once the saplings are ready to be outplanted, they work with community members to outplant them in the surrounding landscape. They also reported discussing with local communities problems pertaining to local environmental degradation and ways that they can help to conserve the environment.

The department of Malem reported that forest surveys are conducted by members of local populations through the facilitation of local collectives.

> *"Usually, the local collective will conduct a forest survey, and will incentivize members of the community to help. In return, individuals that contributed to the survey will be given greater access to the forest. That is what they do."*

> *"You see, we used to go to the villages. Now, the mayor or village chief will come to Malem, to our office, to obtain information. This is how we have begun to work towards transferring competence and knowledge regarding forest management. Now, the local communities, they own the forest, and they manage it through the local collective. The local collectives have made big steps."*

Within the department of Koungheul, it was reported that they often utilize local collectives when engaging with local communities. They stated that local collectives are utilized to: collect information from members of the local population regarding the state of the forests; disseminate information regarding forest management; execute annual work plans regarding producing and outplanting tree saplings; and to host trainings related to tree nursery creation and management, outplanting, and beekeeping. The department of Koungheul seemed to display a more developed working relationship with local collectives and communities, stating that,

> *"Here, we have a very good rapport with the people, and sense of community. We know the local collectives, and the local collectives know the local populations."*

7.2.2 Forest Changes

7.2.2.1 Forest Changes from 1987-2017 and 2002-2017

All four key informants reported that forests had decreased in their respective departments from 1987-2017 as well from 2002-2017.

7.2.2.2 Causes of Forest Changes

Within all four departments, key informants stated that forests had primarily decreased due to anthropogenic factors and that the secondary cause of forest decline was due to decreased precipitation over the past 15-20 years.

The departments of Birkelane and Malem both reported that the anthropogenic factors that had led to forest declines were harvesting trees for the production of charcoal and fuelwood consumption. The key informant within the department of Malem stated that,

> *"Yes, the forests have changed; they are decreasing because people have been damaging the forests. There are not a lot of opportunities for the people, as they do not have access to resources. If they want to cook, they must go into the forest*

to get fuelwood. This is why our forests are decreasing. People need money. They know that by cutting down trees and producing charcoal they are able to make money. Our forests have greatly decreased due to this."

Within the department of Kaffrine, it was reported that forests had mainly decreased due to agricultural intensification because of population increases. It was also stated that an increase in wildfires had been observed due to individuals losing control of fires that had been set to clear land for agriculture.

The department of Koungheul stated that the main cause of forest decline in their department was due to individuals losing control of fires set for agricultural clearing, charcoal production, and cooking. They reported that they do not have the resources to fight these fires, and due to the high volume of fires over time, they have observed subsequent declines in the amount of forested areas. The clearing of land for agricultural cultivation was also mentioned as a factor related to forest decline.

7.2.3 Impacts of Forest Change

7.2.3.1 Eaux et Forêts

All four departments stated that the workload for their offices had increased due to forest changes and that they did not have enough resources to deal with the outcomes of these changes. The department of Birkelane reported that,

The changes have greatly affected Eaux et Forêts. We do not have a lot of strength and we do not have many resources, because of this it is difficult for us to take action and to protect against these changes. The services that we are able to offer have decreased. We do not have enough strength or resources. The changes have been great; they are greater than what we are able to combat. The changes have increased the work that we need to do. This has put pressure on Eaux et Forêts because the results of the changes are greater than what we have the resources to combat. That is how they have affected us."

The department of Malem reported that,

"There is much work to be done because our forests are decreasing, but we are not able to handle all of the work. We do not have enough resources. We do not go to the forest enough. We need to go there more, but we are not able to."

The department of Koungheul stated that,

"It has made it more difficult. The damage is greater than we are able to combat. We do not have enough resources. We work to keep the forests from decreasing, but we are not able to."

7.2.3.2 Local Communities

Each of the four departments in the region of Kaffrine stated that the changes that have occurred in the forests have affected local communities by lowering soil productivity and therefore decreasing agricultural yields.

The department of Birkelane reported that the changes in the environment have put stress on the local communities. The decline in forests has led to a cascading effect of decreased soil fertility, decreased agricultural yields, increased incidences of malnourishment, and decreased abilities of the population to fight off illnesses.

Within the departments of Kaffrine and Malem, the greatest impact to local communities was reported as being decreased soil productivity leading to lower agricultural yields. Additionally, an increased difficulty in obtaining fuelwood for cooking was reported. The key informant from the department of Malem stated that,

> *"These changes have greatly affected the local communities. The local communities live in the bush, when the bush changes, when the forest changes, their lives also change. There are not many trees now, so they have to travel a long ways to find fuelwood. They need fuelwood for cooking. This is very difficult. Also, the soil is no longer productive because we no longer have trees. People have to farm large amounts of land in order to grow enough food. If there is not enough food, there will not be enough money, and people will go hungry. This is all because the forests have decreased."*

Similarly, within the department of Koungheul it was reported that forest declines had led to lower soil productivity and lower agricultural yields.

> *"The changes have caused impacts. For farming, the people do not get high yields. This is because there are no trees, and when the winds come, it causes erosion and the soil is taken away. All of the good soil is removed. People are then unable to get high yields from their fields. They have to use fertilizer, and fertilizer is expensive. You and I know that trees can help to increase agricultural yields. They can be utilized to heal the soil, the environment, but there are no longer many trees. We used to have many, but now they are gone."*

7.2.4 Action

Each key informant reported that their department took action to prevent forest loss through community education and the production of trees in tree nurseries. All of the departments stated that annually their office would produce tree saplings in nurseries that were later distributed to local communities for outplanting. Only the key informant from the department of Birkelane was able to provide me with an amount of tree saplings produced by their office, stating that in 2016 they had produced 126,000 trees. They also reported that a few months after outplanting they were only able to confirm that 2,006 of

the trees outplanted had survived. This is a vivid example of the far greater number of seedlings produced and outplanted than the number of trees that survive after outplanting.

Regarding community education, each key informant reported dispersing knowledge through methods they had previously mentioned in regards to interacting with local communities.

The department of Birkelane stated that to prevent forest loss, they specifically facilitated discussions with local communities regarding agroforestry practices and the prevention of wildfires.

The key informant within the department of Kaffrine reiterated that they discussed problems pertaining to environmental degradation and ways of conserving the environment with the local communities, but also stated that,

> *"I think that there is much importance in increasing materials for capacity training. This would help to increase knowledge for what people can do in the region. It would take two months, or three months. Staff members are able to go throughout the region, doing capacity building trainings and distributing materials. It is difficult to get this started here, but we would be able to do it."*

Within the department of Birkelane, the key informant described dispersing information about forest protection to local communities through a mayor or village chief that visited their office. These visitors then provided the information to local collectives whom subsequently spread the information throughout their communities.

The department of Koungheul also restated their interactions with local communities in regards to taking action against forest lost, reporting that,

> *"We work to prevent forest loss by working with the local communities. We pay one person from a community to come and learn from us. We teach them our annual work plan. They then teach this to the local collective. The collective then works with members of the community, and they work to make tree nurseries. They will outplant the trees in the forest when they are ready."*

7.3 Cluster Analysis

NVivo identified 10 clusters (Figure 7.29) of respondents based on the coding similarity of their interviews. Each node had the potential of being coded for multiple respondents, and therefore could appear in multiple clusters. Clusters 5, 9, and 10 include only one respondent. Within each of the clusters, I identified the top nodes that were discussed by individual respondents through coding percentages, and then identified similarities of focus between respondents in each of the clusters. In summary, Cluster 1 includes the four key informants, Clusters 2 and 3 contain those respondents who believed that forests have been increasing over the past 15 years, and the remaining clusters include

respondents who believe that forests have been decreasing over the past 15 years. Clusters 4 through 10 further group respondents by their beliefs regarding other trends (such as precipitation), causes of deforestation, and actions to prevent or reverse deforestation. Among the clusters of local respondents (Clusters 2-10), no demographic patterns in gender, geography, education, or other features drove a respondent's placement into a specific cluster.

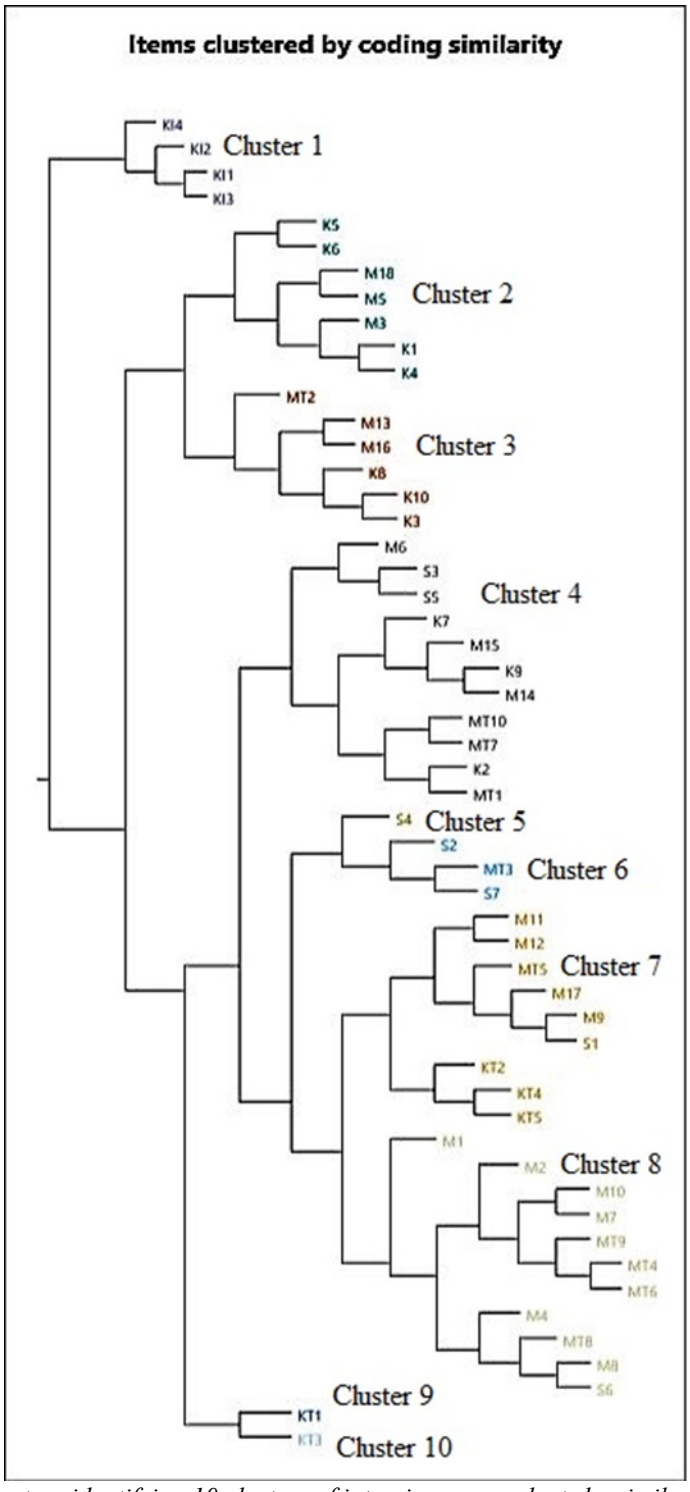

Figure 7.29 *Cluster tree identifying 10 clusters of interview respondents by similarity of coded nodes.*

7.3.1 Cluster 1: Key Informants

This cluster comprised the four key informants interviewed for this study; these four landed in a separate cluster likely due to the different nature of the questions asked of them (Appendix B.2). Key informants talked about similar themes including: Eaux et Forêts; efforts to prevent deforestation; outreach and extension; decreasing forests; soil fertility; food security; deforestation; and climate change. Based on coding percentages, key informants predominantly focused on the themes of efforts to prevent deforestation, outreach and extension, and decreasing forests. Where these themes overlapped with those of the local community (e.g., decreasing forests, food security), the manner in which the key informants discussed these topics was different from the way that individuals from the local communities discussed them (and hence drove their separation into different clusters). Given that I have already discussed the results of the key informant interviews in depth, I will not discuss this cluster further.

7.3.2 Cluster 2: Increasing forests, Efforts to prevent deforestation, Decreasing tree species

This cluster focused on seven respondents that perceived forests to have increased by half or more than half in the 2002-2017 period, and were actively taking part in efforts that either prevented deforestation or increased reforestation.

All seven respondents reported having planted either fruit or native tree species in their fields or in the surrounding landscape, and directly attributed increasing woody cover to these plantings. These respondents also described participating in farmer managed natural regeneration (FMNR), changing harvesting practices, alerting Eaux et Forêts to illegal harvesting, and reducing wildfires.

Additionally, each of the respondents referenced at least one tree species that they perceived to have disappeared, or to be decreasing, on the landscape.

All of the respondents cited farming as their primary occupation, and none reported having a secondary occupation. Of the seven respondents, six had not attended state school for any length of time, while the seventh had completed state school through the secondary level. Four of the respondents resided in the department of Koungheul, while the remaining three resided in the department of Kaffrine.

7.3.3 Cluster 3: Increasing forests, Water security, Increasing tree species

In this cluster, six respondents perceived forests to have increased by more than half from 2002-2017, referenced at least one tree species that they believed to be increasing on the landscape, and also talked about concerns related to water security. Clusters 2 and 3 are closely related due to this common factor of believing forests have increased in the past 15 years.

Each of the respondents reported a belief that forests would continue to increase in the future, despite also expressing concerns related to water security. All stated that there was not enough access to limited water resources on the landscape. Half reported that although they perceived precipitation levels to be increasing, there still was not an adequate amount of accessible water to meet their needs as well as the needs of the environment. The other three respondents stated that they perceived precipitations levels to have been decreasing.

Of these respondents, none had attended state school for any duration of time. All reported their primary occupation as farming, except for one whom reported primarily being a mason. Three of the respondents resided within the department of Koungheul, while two were from the department of Kaffrine, and one resided in the department of Malem.

7.3.4 Cluster 4: Decreasing forests, Deforestation, Decreasing tree species

The respondents in this cluster all stated that they perceived forests to have been decreasing from 1987-2017 as well as from 2002-2017, and their responses focused heavily on tree species that they believed to be decreasing or having disappeared on the landscape.

Eleven respondents were placed in this cluster. Of those 11 respondents, all stated that forests had been declining and that they would continue to decline in the future due to overharvesting or not planting trees to replace the ones that had been harvested. Additional causes of forest decline discussed included pastoralism, water scarcity, and lack of protection provided by Eaux et Forêts.

This cluster heavily focused on tree species that were believed to be decreasing or had disappeared on the landscape. The number of tree species that respondents referenced ranged from three to 13, with respondents referencing seven tree species on average.

No consistent demographic commonalities were identified among the 11 respondents in this cluster. They ranged across age group, gender, department, religious education level, and primary occupation. Of the 11 respondents, nine reported having not attended state school for any duration of time, but this is proportionate with the total number of respondents (84%) that reported having never attended state school.

Cluster 5: Access to traditional medicine, Decreasing forests, Deforestation

One respondent was identified in this cluster, although it was in close proximity, and therefore similar, to Cluster 6 on the dendrogram. The respondent varied from other respondents as their primary occupation was as a traditional healer, and therefore they primarily talked about how forest decline and deforestation related to access to trees that were used for traditional medicine. Fourteen other respondents talked about access to

traditional medicine, but their primary occupation was not that of a traditional healer and they did not focus on the theme as heavily as this respondent did.

The respondent stated that forests had been in decline from 1987-2017 and 2002-2017, and that the forest had declined by more than half. They expressed the belief that the forest had been declining due to deforestation from overharvesting, and stated that the decline would continue to occur in the future, as they did not believe that people would change their harvesting practices.

The respondent resided in the department of Birkelane, had never attended state school, and declined to state how many years they had attended religious school.

7.3.5 Cluster 6: Decreasing forests, Deforestation, Food security, Decreasing tree species

This cluster consisted of three respondents who all perceived that the forest had been in decline from 1987-2017 as well as 2002-2017, and that the decline would continue into the future. All three focused upon themes related to food security, deforestation, and tree species that have decreased or disappeared from the landscape.

The three respondents were specific in that they believed the forest decline was due to deforestation related to overharvesting. They reported the production of charcoal, the collection of animal fodder, and the collection of fuelwood as activities contributing to the overharvesting of trees. Two of the three respondents also reported agricultural expansion as a factor related to deforestation.

Each of the three respondents expressed concern over decreased food security due to a decline in fruit bearing tree species. Thirty-four of the other respondents expressed a concern over food security, but they spoke of it in passing rather than placing a heavy emphasis on it.

Two of the respondents referenced four tree species that they believed to be decreasing or having disappeared from the landscape, while the third referenced 10 species.

All of the respondents in this cluster were male, which is surprising as they all placed a heavy emphasis on concerns over food security relating to decreases in fruit producing tree species and women are typically the ones responsible for gathering forest food products and cooking. Two of the three resided in the department of Birkelane, while the third resided in the department of Malem.

7.3.6 Cluster 7: Decreasing forests, Decreasing tree species

In this cluster, all nine respondents perceived forests to have been in decline from 1987-2017 as well as 2002-2017, and stated that they believed the decline would continue to occur in the future. Of the nine respondents, seven of them reported that the forest had

declined by more than half. The other two respondents stated that, the decline had been by half or less than half.

All of the respondents cited overharvesting as a contributing factor to the decline in forests. Additionally, pastoralism, not planting trees, decreased precipitation, poor soil fertility, growing population pressures, and lack of protection from Eaux et Forêts were mentioned as variables related to forest decline.

There was a heavy emphasis placed on tree species that were believed to have been in decline, or had disappeared, on the landscape. On average, respondents referenced seven tree species, with the number of tree species listed ranging from three to 13.

The majority of the respondents in this cluster (7) resided in the department of Kaffrine, with the remaining two respondents residing in the departments of Malem and Birkelane. Of the nine respondents, eight reported having attended Koranic school for an average of 6.5 years. Additionally, seven of the respondents stated that they had not attended state school for any duration of time.

7.3.7 Cluster 8: Decreasing forests, Community governance, Decreasing tree species

Eleven respondents made up this cluster. The common prominent themes discussed by these respondents included a perception of decreasing forests from 1987-2017 as well as 2002-2017, deforestation, community governance, and tree species that they perceived to be declining, or having disappeared, on the landscape. Clusters 7 and 8 are relatively similar due to their proximity on the dendrogram, but Cluster 8 was separated into its own cluster due to the discussion of community governance.

All of the 11 respondents stated that forests had declined from 1987-2017 as well as 2002-2017, and that they believed that they would continue to decline into the future. Seven of the respondents reported that the decline had been greater than half, while two stated that the decline had been half, and the remaining two reported that the decline had been less than half.

Each of the respondents within this cluster stated that their community had spoken about the decline in forests and the need for a solution, but all but one respondent stated that their community had not taken action after speaking about the need to do so. The one respondent that stated their community had taken action to reduce forest decline reported that they had formed a commission that met annually to talk about how to protect the forest and keep people from damaging it. It was unclear if direct action resulted from the formation of this commission. The need for additional governance from the community to reduce forest decline was expressed by the majority of respondents in this cluster (54%).

Deforestation due to overharvesting was reported as a contributing factor to the decline in forests by all 11 of the respondents in this cluster. Additionally, respondents mentioned agricultural intensification, pastoralism, and pressures due to growing populations as contributing factors to deforestation. Two respondents in Cluster 6 and one respondent in Cluster 2 also mentioned pressures due to population growth.

On average, the respondents in this cluster cited 3.7 tree species that they believed had decreased, or disappeared, on the landscape. The number of references of tree species ranged from eight to two.

A little over half of the respondents in this cluster were from the department of Kaffrine, with the remainder mainly being from the department of Malem, while one respondent was from the department of Birkelane. All but two of the respondents were male, and all but one reported having never attended state school. The one respondent that reported having attended state school stated that they had only attended for one year.

Cluster 9: Efforts to prevent deforestation, Financial security, Outreach and extension

This cluster included just one respondent who was a female head of household, and therefore the primary income generator for her family. Additionally, she had a long history of working with Peace Corps and Trees for the Future, making her similar to a key informant.

She had been a part of Peace Corps Senegal's Master Farmer Program for eight years, and had begun working with PCV's prior to becoming a Master Farmer. She did not state how long she had been working with Trees for the Future, but she did state that she had started working with them prior to her affiliations with Peace Corps.

She had an interesting perspective as she primarily related the planting of trees to income generation, such as planting a live fence to protect her field, planting trees within her field to increase soil fertility and water retention, and planting fruit producing tree species to sell the fruit or seeds. These are all concepts that she reported were extended to her by either Peace Corps or Trees for the Future.

Additionally, she also spoke extensively about individuals propagating trees to plant on the landscape, specifically native tree species that were known to be in decline. Yet, she also stated that she herself did not partake in these activities, although she knew of the need to do so.

She resided in the department of Kaffrine, reported that she had never attended state school, and had only attended religious school for two years.

Cluster 10: Efforts to prevent deforestation, Desertification, Deforestation

This cluster consisted of one respondent who spoke extensively regarding desertification, deforestation, and the efforts that he had made to combat deforestation.

Although this individual's primary occupation was farming, he also had worked with PCV's for a number of years, had been affiliated with and had hosted multiple trainings for Trees for the Future, and worked as a tree nursery propagator for Eaux et Forêts in the department of Kaffrine. This program, of employing members of the local community to create and manage tree nurseries, was mentioned by the key informant from the department of Kaffrine as a way that they work with local communities. Due to his respective affiliations, he was similar to a key informant as he had extensive knowledge regarding the present state of the environment and had participated in multiple activities regarding the prevention of deforestation.

Most notably, the respondent reported that he had begun disseminating the knowledge that he had gained from his respective affiliations to individuals in neighboring villages, by hosting trainings for anyone interested in learning how to propagate trees. He also distributed tree seeds to those that attended his trainings, along with tree sacks that had previously been provided to him and he then recycled for re-use.

Although he reported having never attended state school for any duration of time, the respondent had attended religious school for seven years.

7.4 Remote Sensing Data

To corroborate local perceptions of forest change for the period of 2002-2017 I obtained data for the region of Kaffrine and each of its departments from Global Forest Watch (GFW) regarding:

1. Tree cover loss from 2001-2017 at >10% canopy cover;
2. Extent tree cover for 2000 and 2010 at >10% canopy cover;
3. Tree cover gain from 2001-2012 at >50% canopy cover.

Results from tree cover loss, tree cover gain, and tree cover extent cannot be compared against each other due to variations in research methodologies and date of data collection. Tree cover refers to all vegetation that is greater than 5 m in height. Canopy cover is the percentage of ground area that is covered by the vertical projection of tree crowns. Tree cover loss is defined as the complete removal of tree cover canopy at the 30 m resolution scale (Hansen et al. 2013a).

Table 7.17 *Tree cover loss (ha) at >10% canopy cover from 2001-2017 within Sénégal, the region of Kaffrine, and each of Kaffrine's departments.*

Location	Tree Cover Loss (ha)
Sénégal	117,791
Kaffrine	6
Birkelane	1
Kaffrine	4
Malem	0
Koungheul	0

Although data obtained from GFW did not show substantial tree cover loss at >10% canopy cover from 2001-2017 (Table 7.17), the greatest amount of tree cover loss occurred in the department of Kaffrine (Hansen et al. 2013a). The minimal amount of tree cover loss noted throughout the region is potentially due to GFW being geared towards "proper" forests rather than savanna cover types that are prominent throughout the region, meaning that isolated trees that do not cover the majority of an entire pixel (30 m x 30 m) will be missed in their evaluations of forest cover and change. Therefore, the potential exists for a greater loss in tree cover to have occurred than was documented by GFW. To yield more detailed results regarding tree cover loss in savanna cover types, a time series remote sensing imagery with a finer resolution such as SPOT satellite imagery likely needs to be utilized.

Table 7.18 *Tree cover extent (ha) at >10% canopy cover in 2000 and 2010 within Sénégal, the region of Kaffrine, and each of Kaffrine's departments.*

	Tree Cover Extent (ha)		
Location	2000	2010	% Change
Sénégal	4,785,218	3,447,219	-28.0
Kaffrine	1,656	1,373	-17.1
Birkelane	330	599	81.5
Kaffrine	1,099	488	-55.6
Malem	34	71	108.8
Koungheul	192	215	12.0

Tree cover extent decreased between 2000 and 2010 in Sénégal and in the region of Kaffrine as a whole (Table 7.18) (Hansen et al. 2013a). Interestingly, the departments of Birkelane and Malem experienced strong positive percent increases in forest cover extent, yet in the department of Birkelane 100% of respondents reported decreases in perceived forest cover and 80% of respondents in the department of Malem reported perceived decreases in forest cover, as can be seen in Table 7.2 from the section *Perceptions of Forest Change 2002-2017*. In the department of Koungheul, where 70% of respondents reported perceived increases in forest cover, the percent change of tree cover extent,

while still positive, was not as strong as that experienced within the departments of Birkelane and Malem.

The department of Kaffrine showed a negative percent change of tree cover extent, and also displayed a loss 4 ha loss of tree cover, yet only approximately 2/3's of respondents from the department of Kaffrine reported a perceived decrease in forest cover from 2002-2017.

Table 7.2 *Local respondents' perceptions of forest change throughout the region of Kaffrine from 2002-2017 by department.*

Location	Decreased		Increased	
Department	**Number of Responses**	**Percent (%)**	**Number of Responses**	**Percent (%)**
Birkelane (7)	7	100.0	0	0.0
Kaffrine (23)	17	73.9	6	26.1
Malem (10)	8	80.0	2	20.0
Koungheul (10)	3	30.0	7	70.0
Region (50)	35	70.0	15	30.0

Tree cover gain was investigated at >50% canopy cover by GFW from 2001 to 2012. There were no gains in forests with greater than 50% canopy cover. We are unable to determine if gains in tree cover occurred that were less than the >50% canopy cover measurement that GFW utilized. GFW maps tree cover gains at a >50% canopy cover interval, as it was designed to investigate metrics directly related to deforestation in forests, rather than gains in forest cover in savanna biomes. This is a much greater canopy cover than the savanna cover types present in the region are expected to display. It is possible that the departments of Malem and Koungheul, and perhaps Birkelane, experienced gains in tree cover that were not identified due to the high level of canopy cover utilized in the evaluation.

Due to the relatively small amounts of change in tree cover loss and tree cover extent noted at this level of resolution, maps do not illustrate perceivable changes. Therefore they are not displayed here.

8 DISCUSSION

Local communities did not prove to be a good judge of overall forest increases or decreases within their departments as reported by GFW. These inaccuracies are likely a result of the presumption of the geographic scope that would be covered by local perceptions and the scale and resolution at which GFW collects and interprets data. Instead, their perceptions were likely more reflective of a smaller scale, such as the areas surrounding their communities where the majority of their activities on the landscape take place. They displayed a detailed knowledge of changes in forest cover, tree species abundance, wildlife abundance, and the availability of resources such as fuelwood and traditional medicines in these areas. Additionally, Eaux et Forêts appears to be lacking current data regarding the state of forests within the region as well as the capacity to collect it, and they also seem to have a pronounced lack of influence with local communities. The interaction of Eaux et Forêts with local communities is an area that is in need of additional research, along with changes in forest cover surrounding villages, and the current population dynamics of tree species and wildlife. I also suggest that extension activities be developed in a number of areas including: extension activities geared towards women; agroforestry; FMNR; and native tree species propagation.

8.1 Geographic Differences (Actual versus Perceived) in Forest Losses and Gains

Based on the results from GFW, the departments of Birkelane, Malem, and Koungheul experienced a gain in forest cover extent from 2001-2010, while the department of Kaffrine experienced a loss. Yet interestingly, local respondents and key informants did not seem to perceive this accurately; most reported a perceived decline in forests.

In the department of Birkelane, where there was an increase in tree cover extent of 81.5% from 2000-2010, all of the respondents stated that forests had declined from 2002-2017. A little over half of them reported a decline greater than half, primarily due to overharvesting. Additionally, the majority of respondents stated that there had been decreases in shade in the forest, the distance to collect fuelwood had increased by approximately 0.6 km, and the abundance of wildlife had decreased over this period.

Within the department of Malem, GFW reported an increase in tree cover extent of 108.8% from 2000-2010, yet 80% of the individuals interviewed reported a decline in forests from 2002-2017, primarily due to overharvesting and perceived declines in precipitation. The majority of respondents also believed that the amount of shade on the landscape had decreased, the abundance of wildlife had decreased, and the distance to collect fuelwood had increased by approximately 2.4 km.

The department of Koungheul experienced only a 12% increase in forest extent from 2000-2010 according to GFW, yet unlike the other departments, the majority of respondents within the department of Koungheul did state that forests had increased from

2002-2017. People were mostly unsure as to the reason why forests had increased, but a few did attribute the increase to planting trees and declines in charcoal production. The majority of respondents also believed that the increase in forest cover had been greater than half and that shade had also increased on the landscape. Even so, most respondents reported that the distance to collect fuelwood over this period had increased by approximately 2.2 km, and people were split on whether wildlife had increased or decreased in the area.

The department of Kaffrine was the only department that experienced a decline in tree cover extent, -55.6%, from 2000-2010 according to GFW, with a 4 hectare loss of tree cover from 2001-2017. Approximately 74% of respondents in the Kaffrine department reported a perceived decline in forests over this time, which was mainly attributed to overharvesting. As this was the only department to have experienced a decline in tree cover extent, I would have expected the proportion of individuals who reported a decline in forests to have been greater. Of those that reported a decline, many felt that the decline had been greater than half. A larger majority of respondents reported a decrease in shade on the landscape (86.7%), declines in wildlife abundance (87%), and an increase in the distance to collect fuelwood by approximately 1.8 km (95.7%), than reported a decrease in forests.

As the department of Kaffrine has the greatest population size, and has the second smallest land area of all the departments, it likely experiences greater pressures from the population on forest resources, and therefore has experienced an overall loss in tree cover and tree cover extent, unlike the other departments.

More intriguing than the responses of members of the local population, were the responses of the four key informants interviewed. Each of the key informants stated that the forests within their respective departments had decreased over the period of 2002-2017 due to anthropogenic factors and decreased precipitation. While a loss of forest cover extent did occur in the department of Kaffrine, this was the not the case for the remaining departments. Although the key informants reported that the Centre de Suivi Écologique (CSÉ) conducts a national forest inventory through remotely sensed imagery every 15 years to monitor the state of the nation's forests, this was last done in 2002 and a new report had not yet been received. Key informants therefore did not have up to date information based on remotely sensed imagery regarding the extent of the forests in their jurisdictions. Additionally, each of the key informants stated that they monitored forests in their respective departments through annual visual forest inventories without the aid of additional references such as photographs. The key informant within the department of Kaffrine explicitly stated that a visual inventory was not sufficient, and that forests needed to be monitored through a photo inventory so that they would be aware of deforestation and reforestation trends. While each of the key informants had a multi-year history of working for Eaux et Forêts, none had worked within the department of Kaffrine for greater than 5 years. I am therefore hesitant to trust the accuracy of results from annual visual forest inventories that take place between the national forest inventories and that do not utilize additional references or consistent indicators.

The key informant within the department of Koungheul did mention that they also utilized information provided by local collectives from community members to monitor forest changes. He reported that it was necessary to utilize information provided by local collectives, as Eaux et Forêts did not have enough resources to effectively monitor forest changes on their own. As the majority of local respondents accurately gauged that forests had increased in the department of Koungheul, it appears that there is a disconnect between the perceptions of local communities and the information that is being provided to, or collected by, Eaux et Forêts in the department of Koungheul.

There is a possible explanation for why so many reported forest losses, while remote sensing data evidenced gains. Forest cover may have continuously decreased in the areas immediately surrounding communities of the respondents, due to pressures placed on forest resources from overharvesting, while forest cover may be increasing in areas that are far from inhabited spaces and do not experience the same anthropogenic pressures, such as classified forests or forest reserves. This would explain why the majority of participants in the departments of Birkelane and Malem believe the forests have decreased, even though they have been shown to be increasing, and why the majority of participants in the department of Koungheul believe the forests have increased, but still report increased distances to collect fuelwood. This inference is supported by the finding of Mbow et al. (2008) that individuals residing within Eastern Saloum held the belief that land far from settlements had been improving in the recent past.

8.2 Role of Eaux et Forêts in Village Forest Management

One predominant theme in this study was the disconnect that seemed to exist between the interactions that Eaux et Forêts reported having with local communities and the lack of reported interactions with Eaux et Forêts from respondents within the local communities.

Each of the key informants placed a strong emphasis on working with local communities, mainly through local collectives. Yet, not a single local respondent mentioned local collectives. In fact, Eaux et Forêts was only referenced 17 times by 12 local respondents (24%), and 4 of those local respondents specifically mentioned Eaux et Forêts to express that they did not feel that they were adequately performing their job.

> *"…when people cut trees, or dig up their roots repeatedly, they die. You know Eaux et Forêts; it is their job to protect the forest. They are not doing that."*

The results of the cluster analysis further demonstrated this disparity. Based on coding percentages, outreach and extension was the second most talked about theme by key informants in Cluster 1, only following the theme of efforts to prevent deforestation. Eaux et Forêts was a node that was specifically coded for amongst local respondents, and yet it did not have high enough coding percentages to be brought out as a key theme within any of the clusters containing local respondents. In Cluster 8, where individuals placed a heavy emphasis on community governance, (where one might assume that Eaux et Forêts would be mentioned due to the heavy emphasis Eaux et Forêts places on

interacting with local communities), only two of the 11 individuals referenced Eaux et Forêts. One stated that people alert Eaux et Forêts to illegal harvesting practices, and the other expressed discontent with Eaux et Forêts' conduct.

> *"...people speak with Eaux et Forêts so that they know who is illegally cutting trees, and if a person is selling illegally harvested trees they are able to stop them."*

> *"The forests have not been protected. Eaux et Forêts, they are spending their salaries, but they are not leaving their offices. They are not going out into the forests, and the forests are suffering because of this."*

In the department of Koungheul, which seemed to display the most mature working relationship with local collectives and communities, 40% of the local respondents mentioned Eaux et Forêts, and all in a positive light referring to either trainings Eaux et Forêts had conducted or actions they had taken regarding forest management.

> *"The trees are starting to come back now. A short time ago, they had all been cut for making charcoal. During the dry season, people would burn the forest, and all the trees would die. This happened a lot here. However, Eaux et Forêts came, and they taught us about protecting the forest. They helped us by bringing materials, and we were able to start making tree nurseries."*

This relationship not only yielded positive feedback from community members, but also seems to have yielded substantive results as the department of Koungheul had the greatest percentage of respondents that reported planting trees and taking action to prevent forest loss. It was also the only department that reported alerting Eaux et Forêts to illegal harvesting practices as an action taken to prevent forest loss, demonstrating that they have confidence in Eaux et Forêts' ability and willingness to take action.

Conversely, in the department of Kaffrine, the key informant stated that local collectives were still in the beginning stages of development, and that in lieu of local collectives, they had established a program that employed members of the local community to create and manage tree nurseries. The individual from Cluster 10 is one of these individuals, but interestingly, he stated that he was the only individual involved in this program in the department of Kaffrine.

> *"I am a farmer, and I plant trees. I have a program with Eaux et Forêts. They came here and saw my work with growing trees, and they were very happy with it. They now pay me to grow trees in my tree nursery and they then transport the seedlings to other villages to be planted. My problems are with water. I have to pay for the water in my field. If I have the money to pay for water, I am able to water all of the*

trees. Right now, I am able to do it. Thank Allah. Eaux et Forêts gave me the only program in the department of Kaffrine for growing trees. I want to grow many trees for them, but having enough water is difficult. If the seeds do not germinate for lack of water, I am not able to do this program."

Additionally, only four of the 23 respondents in the department of Kaffrine, including the one mentioned above, spoke of Eaux et Forêts, and the other three spoke negatively of them when they did so.

In the department of Birkelane, four of the seven respondents did mention Eaux et Forêts, with none stating that they were content with the services that had been provided. No respondents in the department of Malem mentioned Eaux et Forêts.

It seems that there is a pronounced lack of influence of Eaux et Forêts in the local communities. The key informants repeatedly emphasized their lack of resources being a key factor in their need to rely on local communities for the monitoring of forest changes (indicating that they do not have the current capacity to collect this information themselves), but it appears that Eaux et Forêts has not done enough to establish these relationships and needs to make their presence more strongly felt within the local communities. Due to the display of local support for tree planting and other forest conserving activities, the department of Koungheul should be looked to as a model by the other departments for developing these relationships and supporting locally driven forest management. Even so, the department of Koungheul also has additional work that needs to be done towards developing these relationships. Moreover, all of the departments need to increase their capacity for monitoring forest changes by designing a set of indicators that can be consistently measured through time. This would be most useful if all of the departments worked together to design a set of indicators that were then used across all departments to measure forest change throughout the region.

An alternative explanation for the disconnect that I found between the amount of interaction between Eaux et Forêts and local communities reported by key informants and local respondents, is potentially due to my data collection methodology. Due to ease of collection, I performed interviews with local respondents prior to interviews with key informants. I therefore was not aware of Eaux et Forêts' strong emphasis on working with local communities and did not specifically ask local respondents about Eaux et Forêts or their interactions with them. Ideally, I would have interviewed key informants first and then utilized their collective responses in my interviews with local respondents. Granted, my research was not focused on the interactions between Eaux et Forêts and local communities, but this issue clearly warrants further research in the future.

8.3 Other Interesting Results

8.3.1 Precipitation

8.3.1.1 Perceptions

Declines in precipitation were a common theme that repeatedly came up throughout interviews. All of the key informants mentioned declines in precipitation as being a contributing factor to forest decline. The key informant from the department of Birkelane went as far as to mention a climate study conducted in the area showing that precipitation had decreased over the past 10-15 years.

> *"A climate change study was done in some of the villages, it showed that ten to fifteen years ago, there was a lot of rain, but now the rains have decreased."*

I was unable to locate this study. Amongst local respondents, declines in precipitation was the most stated non-anthropogenic reason for declines in forest cover, as well as for the continuation of declines in forest cover in the future. This perception of declining patterns of precipitation intuitively makes sense, considering the history of drought over the past half century experienced throughout the Sahel region, including Senegal and the region of Kaffrine.

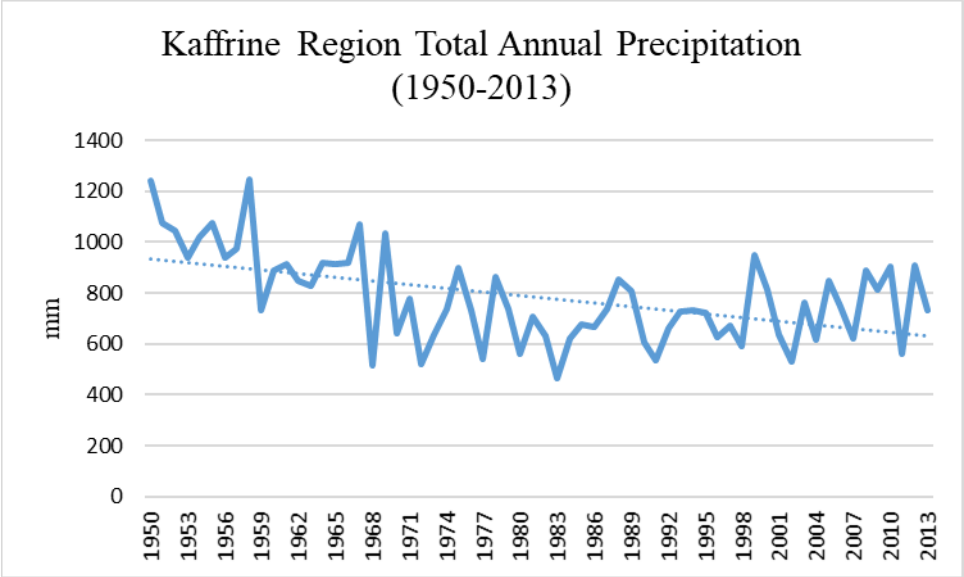

Figure 8.1 *Annual precipitation in region of Kaffrine, 1950-2013. Data source: WCRP 2018.*

I was able to obtain annual rainfall data for the region of Kaffrine from 1950 through 2013 (Figure 8.1) from the World Climate Research Program (WCRP) (2018). While this data does not extend through 2017, we can visualize the significant droughts that occurred during the period of 1968 to 1984 with a decrease in rainfall of 30% compared

to the 1950s (Held 2014) and the general trend of decreased levels of precipitation from 1950-2013 which indicates that precipitation levels have not recovered to pre-drought conditions.

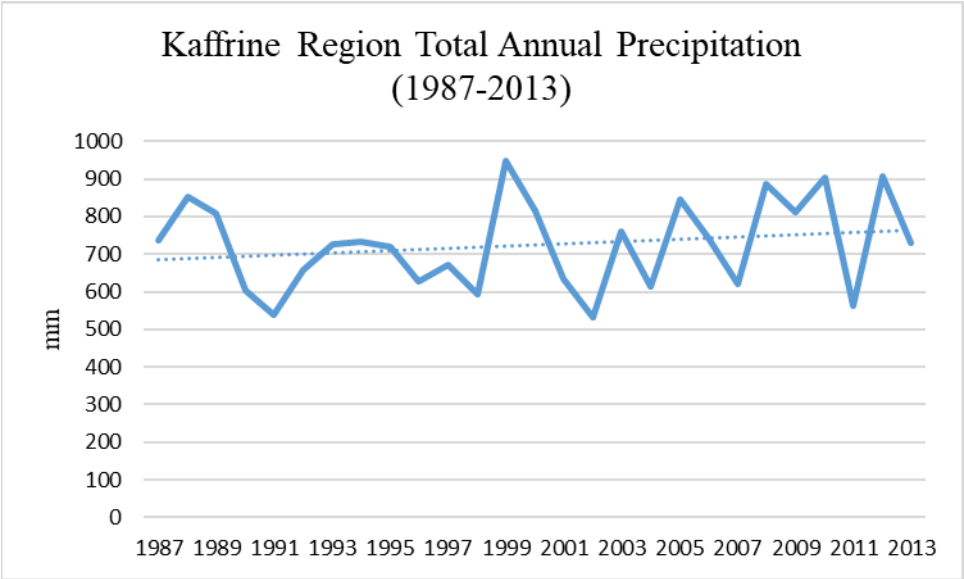

Figure 8.2 *Annual precipitation in region of Kaffrine, 1987-2013. Data source: WCRP 2018.*

Yet, when looking at the period of 1987-2013 (Figure 8.2) we notice that although significant variation in precipitation levels have occurred, the overall trend is an increase in precipitation.

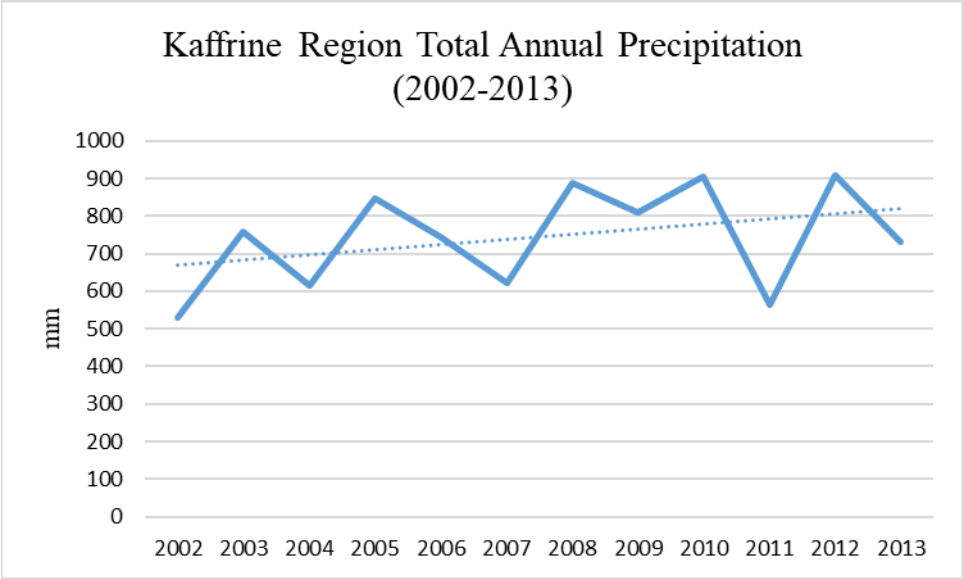

Figure 8.3 *Annual precipitation in region of Kaffrine, 2002-2013. Data source: WCRP 2018.*

The same general trend of increased precipitation is noted when looking at the period of 2002-2013 (Figure 8.3).

These results indicate that the majority of the general population throughout the region of Kaffrine, and all of the key informants at Eaux et Forêts, are not accurately perceiving trends in precipitation. There are a number of explanations that could generate this belief:

1. The high variability in the amount of annual rainfall that has occurred makes it difficult to assess whether the general trend over time is positive or negative;
2. A growing population means increased water requirements. If population growth is exceeding increased precipitations trends, it will likely feel as if precipitation is declining. While I was not able to obtain population growth data for the region of Kaffrine, it can be assumed that a high population growth rate is present here as it is throughout the rest of Senegal where the population is currently growing at a rate of 2.8% annually (The World Factbook 2018);
3. Decreased agricultural yields that are likely due to increased population pressures and/or declines in soil fertility may be misconstrued as a result of water scarcity, leading to the belief that precipitation rates are declining;
4. They are being told that declines in precipitation have occurred by officials, such as members of Eaux et Forêts.

All of the key informants (all high-ranking members of Eaux et Forêts within their respective departments) stated that the secondary cause of forest decline was due to decreased precipitation over the past 15-20 years. I can only assume that they have reached this conclusion without the availability of accurate data. As my research was not focused on precipitation trends within the region, I did not ask where or how they obtained precipitation data, therefore I cannot verify the accuracy of the data they based their conclusions on. I also cannot use it as a comparison for the data that I obtained from WCRP 2018.

It is important to note, that among individuals that reported increases in forest cover, increases in precipitation was a reason stated for those increases. It was also a reason given for the belief of the continuation of increases in forest cover going into the future, although this was minimal. This is an important finding; those that correctly perceived an increase in forest cover also perceived an increase in precipitation, and knew that the two trends are at least possibly correlated.

8.3.1.2 Effect on Environment

Generally speaking, 1,000 mm of annual rainfall is the lower limit for self-sustaining forest, and savanna predominates in areas receiving between 750-1,000 mm of rain; trees cannot grow without irrigation in areas receiving less than 750 mm of rainfall per year and a complete loss of trees occurs at or below 500 mm of annual rainfall (Mayer & Henareh 2011). In the region of Kaffrine, annual rainfall has not fallen below 500 mm since 1983, although it has frequently dipped below 750 mm. Even so, the steady, albeit slight, increase in precipitation should generate an increase in the number of trees.

In the departments of Birkelane and Malem, where people stated that forests are decreasing, but GFW showed an increase in tree cover extent, the trend in increased annual precipitation further corroborates the conclusion that forested areas are decreasing around villages due to overharvesting, but are increasing far from village areas. Additionally, in the department of Kaffrine, where a decrease in tree cover extent was documented by GFW, the increased annual precipitation trend undoubtedly points towards overharvesting as the cause of declines in forested areas. These trends can be verified using time series remote sensing imagery with a finer resolution (e.g. SPOT satellite imagery, with sub-10m resolution available since 1986).

8.3.2 Tree Planting

The vast majority of individuals throughout the region and in each of the individual departments reported planting trees, yet few people reported planting trees as a way of preventing forest loss, and even fewer people reported planting trees in the forest. This lack of replanting trees in forests combined with generalized perceptions of decreasing forests further stresses overharvesting occurring near villages, especially in the departments of Birkelane and Malem, as people are not planting enough trees to offset losses.

Many individuals indicated that planting trees in the forest would be futile, as the survival rate of seedlings and saplings would be low due to uncontrolled livestock grazing and damage from wild animals. This was vividly demonstrated by the Eaux et Forêts official from the department of Birkelane, who stated that although they had produced 126,000 tree seedlings in 2016, they were only able to confirm the survival of 2,006 seedlings a few months after outplanting. Instead, people are mainly planting trees in their fields and home gardens where they have increased protection and higher rates of survival, and they are commonly planting exotic species that produce fruit. These are species that are extended by Peace Corps and Trees for the Future for their ability to increase food and financial security. Given the overharvesting that is occurring near villages for fuelwood and other wood products, it would be advisable for Peace Corps and Trees for the Future to begin extending native tree species that can be planted to meet these needs in addition to the exotic tree species that they are currently extending. Additionally, they should be further promoting the practice of FMNR, so that farmers will be conserving native tree species within their fields that can be used as additional sources of fuelwood.

Additionally, while most people reported planting trees, many people also stated that they had not taken action to prevent forest loss, and that they had not done so because they felt that they were unable to. Throughout the interviews, it seemed that people felt that they did not have the power, or the authority, to take action in areas that they did not have explicit ownership, as they do within their fields or homes. This would suggest that although local communities are supposed to have management, as well as usufruct, rights in community forests through the rural councils, or local collectives, they do not actually feel as if they have these rights. All areas not privately owned or labeled as classified forests or forest reserves, where the state maintains exclusive management rights, are

considered “community forests.” It is possible that local communities do not have or perceive that they have enough control over these forests to manage them.

8.3.3 Gender

Throughout the interviews, gender often did not come into play regarding people’s perceptions of forest change. However, it did seem to influence whether people took action to prevent forest loss, their reasoning for doing so or not doing so, and how they took action. Although most people reported having not taken action to prevent forest loss, a larger proportion of men than women had done so. The main reasons that women gave for having not taken action to prevent forest loss included not knowing how and being unable to do so. Men mostly stated that they had not taken action to prevent forest loss because they were unable to do so; this is likely due to the reason discussed above related to usufruct rights of community forests.

Although the 2001 constitution grants gender-neutral access to land, women are under different constraints than men due to gender roles, and social and religious norms (USAID 2010). We know that the disparity seen for taking action to prevent forest loss between the genders is not due to women being barred from tree nurseries or tree planting, because a high percentage of women (greater than 80%) reported planting trees and having done so in either their homes or fields. Therefore, it is not likely due to land access constraints. I speculate that women stated that they were unable to take action to prevent forest loss due to time and energy constraints related to gender roles and social norms. It is typically the duty of women to cook, maintain the cleanliness of the household, care for the children, gather fuelwood and non-timber forest products, grow market vegetables, and work in their husband’s fields. Women likely do not have the time or energy to dedicate to projects outside of these tasks. Whereas for men, their primary responsibility is to generate income for their family, which is typically done through agricultural cultivation, leaving them with more time and energy to participate in other projects. With respect to the large proportion of women who stated that they had not taken action to prevent forest loss because they did not know how to do so, this is likely because extension activities are typically geared towards men. This finding suggests that more extension resources need to be targeted towards training women in agroforestry practices in the future.

Additionally, differences existed in how the two genders take action to prevent forest loss. Men reported a diverse range of actions such as planting trees, raising community awareness, preventing and fighting wildfires, and alerting Eaux et Forêts to illegal practices. Women on the other hand only named three activities: allowing fields to go fallow, changing their harvesting practices, and least often by raising community awareness. These are the actions that will likely not put additional constraints on women’s already limited time and energy. No women reported planting trees as a method of preventing forest loss. When women do partake in planting trees, they likely do so with the intention of increasing access to food security, therefore potentially decreasing their workload in the future.

8.3.4 Education

I was surprised to find that level of education seemed to have little influence over how people perceived their environment and the actions that they took regarding those perceptions. This is likely due to the majority of participants having obtained similar levels of education, or perhaps a more accurate description would be to say that this is likely a result of the majority of participants having not obtained a state education. Eighty-four percent of respondents reported having not attended state school for any duration of time. Of the remaining 16% (8 participants), their levels of education ranged from one year to a Master's degree, and there was still a large variety in their perceptions.

Most of the participants had attended Koranic school, but no correlations concerning environmental perceptions or actions and Koranic school attendance were observed. I found this even more surprising as there are a number of passages within the Koran that talk about maintaining and protecting the environment (Khalid 2002).

8.4 Results and Broader LEK Knowledge

Several previous studies have demonstrated that LEK of deforestation and other natural resource trends can be fairly accurate and reliable, and can be utilized as a means of conducting ecosystem assessments (Faye et al. 2018; Boissiere et al 2013; Sahoo et al. 2013; Bakhoum et al. 2012b; Gonzalez et al. 2012; Chalmers & Fabricius 2007). On the surface, it may appear that the results of this study do not display the same accuracy and reliability of those previously conducted, as the majority of local perceptions regarding changes in forest extent were inaccurate when compared to GFW data, yet I would argue otherwise. I believe that these inaccuracies are largely a result of the presumption of the geographic scope that would be covered by local perceptions and the scale and resolution at which GFW collects its data.

It was presumed that local perceptions would convey forest trends that were representative of trends on a departmental and regional scale. However, due to the nature of local community member's interactions with their environment, mainly through agriculture and the collection of fuelwood and non-timber forest products, their perceptions more accurately represented trends at a smaller scale, extending a few to several kilometers outside of village areas. Due to anthropogenic pressures, particularly overharvesting, these areas have notably experienced decreases in forest cover. This is not only demonstrated through people's direct perceptions of forest cover trends, but also their perceptions of changes in shade, wildlife abundance, and distances to collect fuelwood. In each of the departments, people's perceptions of forest cover trends were consistent with their perceptions of changes in these other three areas as well, with the exception of changes in distance to collect fuelwood in the department of Koungheul, as was previously discussed. Given the consistency of these perceptions, I do believe that the utilization of perceptions of changes in shade, wildlife abundance, and distances to collect fuelwood act as useful proxies regarding forest loss at a scale relevant to the scope of those perceptions.

As GFW evaluated changes in forest extent on a departmental and regional scale, it does not have the ability to determine changes that are likely occurring at smaller scales. Additionally, as GFW utilizes Landsat satellite imagery at a spatial resolution of 30 m, it is geared towards "proper" forests rather than savanna cover types that are prominent throughout the region, meaning that isolated trees that do not cover an entire pixel (30 m x 30 m) will be missed in their evaluations of forest cover and change. In areas surrounding villages where trees are typically scattered throughout and within agricultural fields, it would be even less likely for GFW to identify the gains and losses in tree cover that are occurring. In the future, further research would be warranted to evaluate changes in forest cover in areas surrounding villages with the utilization of a time series remote sensing imagery with a finer resolution such as SPOT satellite imagery.

8.4.1 Overharvesting

Local community members clearly illustrated that they felt that overharvesting of forest products was a major problem that has led to difficulty locating certain forest products and traveling long distances to do so. These were concerns that were expressed throughout all of the departments, yet only a few people reported changing their harvesting practices. Due to the pervasiveness of these concerns and the lack of appropriate action taken to address them, it would be advisable for Eaux et Forêts, Peace Corps, and local NGOs to increase extension activities in the areas of: alternative cooking fuels; improved cook stoves; farmer managed natural regeneration (FMNR); native tree species propagation; woodlot establishment; and agroforestry.

8.4.2 Tree Species

Herrmann & Tappan (2013) and Bakhoum et al. (2012b) had previously identified *B. costatum, P. erinaceus, C. pinnata, S. setigera, D. microcarpum, L. acida, A. leiocarpus, F. iteophylla, D. mespiliformis,* and *H. insignis* as having disappeared from or being rare/threatened on the landscape. The present study built upon these findings, as it identified all of these species as having decreased or disappeared from the landscape, while also identifying a number of additional tree species that local populations feel have decreased or disappeared from the landscape in the past 10-15 years. Among the tree species that were most commonly identified as having decreased or disappeared from the landscape (Table 7.11), there were nine species that were referenced by at least four respondents and that were not identified in the previous two studies. In particular, *P. biglobosa, F. gnaphalocarpa* (*F. sycomorus*) and *S. madagascariensis*, were all referenced by 10 or more respondents. This suggests that since the completion of the previous studies, a larger proportion of tree species are believed to have come under threat.

The two previous studies utilized forest and woody vegetation surveys to corroborate, and build upon, the findings that they obtained from local population's perceptions. This

would be warranted to confirm the status of the tree species identified as declining or having disappeared from the landscape in this study, as well as tree species that were identified as increasing. Additional research could determine if these species are only declining in areas near villages, due to their common utilization by local populations (overharvesting), or if they are also declining in areas far from village settings where they would not be under the same intensity of anthropogenic pressures.

8.4.3 Wildlife

A majority of members of the local population throughout the region of Kaffrine held the belief that wildlife populations had decreased over the past 10-15 years, although there were discrepancies amongst departments, particularly the departments of Koungheul and Birkelane. Participants were not asked to name species that they believed to have decreased or increased on the landscape, yet a number of participants did so, although there was disagreement regarding whether certain species were increasing or decreasing on the landscape (mainly the spotted hyena (*C. crocuta*)).

Little research has been done in the region, and in Sénégal, regarding the state of change of current populations (ANSD 2015). The presence of large and medium sized mammals is known to be decreasing throughout the Sahel and West Africa, even within most protected areas (Hema et al. 2017; Walther 2016). This trend is also believed to be occurring in the region of Kaffrine, but it has not been confirmed (ANSD 2015). The IUCN focuses on population dynamics and trends across a species entire geographic range, and does not report population dynamics for a species in a selected country or region. A quick Google Scholar (Google, Mountain View, CA) and Web of Science (Thompson Reuters, New York) search yielded few results for the population status within Sénégal of the species referenced by participants. Population statistics within Sénégal were available for the spotted hyena (*C. crocuta*) with an estimated population of 100-1,000 (Mills & Hofer 1998), lions (*P. leo*) with population estimates of 15-106 (Riggio et al. 2013; Henschel et al. 2014; Kane 2014), leopards (*P. pardus*) with estimated populations between 162-403 (Henschel et al. 2014; Kane 2014), and Guinea baboons with a population estimate of 3,370 within Niokolo-Koba National Park (Renaud 2006).

Additional research related to wildlife populations is clearly warranted in the future, due to the lack of previous data, the overall perception of wildlife decline throughout the region, and the discrepancies in perceptions of changes in wildlife abundance amongst the departments.

8.5 Caveats/Limitations of Study

These results are drawn from a limited number of interviews (50 local community members and 4 key informants). In order to obtain statistically significant results, a sample size of approximately 400 would have been warranted. I did not have the time or

resources to acquire a sample of this size. Since I used a snowball sampling method in villages where other PCVs resided, these data are likely biased, as individuals who have a connection to a PCV are more likely to think about forest trends and management simply due to their exposure to the PC program. Since I spoke with individuals that were initially introduced to me through PCVs, this likely excluded many individuals that did not have a connection with the PCV. Due to my small sample size, and the likelihood of bias, my discussion and conclusion cannot be considered as providing definitive answers at a country scale. Additionally, the use of GFW's data at 30 m resolution yielded minimal results regarding forest loss and gain. Remote sensing at this resolution was not sufficient to detect changes in the savanna cover types that are prominent throughout the region, and it likely missed isolated trees that did not cover an entire pixel (30 x 30 m) in their evaluations of forest cover and change. To yield more detailed results regarding tree cover loss in savanna cover types, a time series remote sensing imagery with a finer resolution such as SPOT satellite imagery likely needs to be utilized.

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A Appendix A

A.1 Waiver of Written Informed Consent Request

I will be working with a population with a low literacy rate, and whose primary language is Wolof; they are not accustomed to signing forms. A written consent may be intimidating and/or impractical. I am requesting a waiver of written consent and plan to orally inform participants about my study, and their rights to participate. I speak a common language, conversationally, with the participants. As I want to ensure complete understanding throughout the interview process, an individual whose first language is Wolof will be utilized to ensure proper translation, and clarity, of interview questions. I will document participant consent by means of audio recording. I will not ask subjects to identify themselves by name. I will safeguard confidentiality by giving each interviewee a numerical code that their information will be recorded under. Corresponding identifying information will be kept in a separate work journal that will be kept on my person during fieldwork, and in a locked trunk at the Peace Corps Regional Office in Kaffrine, that only I have access to, when fieldwork is not being conducted. All digital data, including audio interviews, transcriptions, translations, and coding, will also be kept in a locked trunk at the Peace Corps Regional Office in Kaffrine.

A.2 Oral Informed Consent Request (Delivered in Native Language)

I am a graduate student and Peace Corps Volunteer from Michigan Technological University in the United States. I am conducting a study at my school to complete my Master's degree in Forest Ecology and Management. I am conducting research to complete my academic degree. I would like to talk to you about your perception of forest cover change over the past 10-30 years, and its causes and effects. I would like to tape record our conversation, so that I can accurately record your response. You may ask me to turn off the machine at any time if you become uncomfortable. I will also take notes throughout the interview. The entire interview process should take 45 minutes to an hour.

You may ask me questions at any time and talk about things you think I should know about, even if I do not ask. You should feel free to interrupt me if you want to ask questions about forest cover change in the region of Kaffrine. You are not required to talk to me or answer my questions. Even if you decide now to talk to me about forest cover change in the region of Kaffrine, you may ask me later to stop asking you about it. When you ask me to stop, I will stop asking you about forest cover change in the region of Kaffrine. Nothing bad will happen to you, or me, if you decide to not answer my questions about forest cover change in the region of Kaffrine.

I will not reveal anything that you say to me, beyond anyone helping me whom I trust to maintain your confidentiality. I will do everything I can to protect your privacy, but there is always a slight chance that someone could find out about our conversation.

The Michigan Tech Institutional Review Board (Michigan-Tech IRB) has reviewed my request to conduct this project. If you have any concerns about your rights in this study, please contact MICHIGAN TECH-IRB at +1-906-487-2902, or email IRB@mtu.edu. If you have any questions regarding your interview, or my research, feel free to contact me, Rhiley Allbee, at +221771169682 or reallbee@mtu.edu.

I am asking if you would agree to participate in this study, and to talk to me about your perception of forest cover change in the region of Kaffrine. Do you agree to participate? Will you allow me to tape record our conversation?

B Appendix B – Interview Questions

B.1 Community Interview Questions

Background/Demographic Questions

1. What is your age?
2. Where do you live, and how long have you lived there for?
3. What level of schooling have you obtained?
4. What is your work?
5. How long have you been doing this work?
6. Do you use trees in your work? How?
7. What kind of trees do you use?

Forest Changes

1. Have trees become more, or less, abundant on the landscape over the past 20-30 years? In the past 10-15 years?
2. How much more, or less, abundant have trees become? Can you estimate this change (half, less than half, more than half) and/or describe it (e.g. shade, distance for fuelwood, changes in wildlife, etc.)?
    a. Has the amount of shade increased or decreased?
    b. Do you have to walk farther to collect fuelwood? How much farther?
    c. Have wildlife populations increased, or decreased?
3. Are there trees that used to be located in the environment that are no longer present, or that are now hard to find? Which ones?

Continuation of Forest Change, and Causes

1. Do you think that the decrease, or increase, of trees will continue to occur? Why?
2. Why do you think that the decrease, or increase, of trees has occurred?

3. How much have you or your community talked about the forest changes? What is discussed?

Effect of Forest Change on Community

1. Is it difficult to find trees for your work?
2. Do you have to travel long distances to find trees for your work? How far?
3. Have these distances increased since you began doing your work? How much have they increased?
4. Do you think that the changes in trees in the environment have been beneficial, or non-beneficial, changes? How?
5. Who will be most affected by forest changes (e.g., the current population, younger generations, everybody, nobody, others, do not know)?

Action

1. Have you taken action to prevent forest loss? How?
2. Have you planted trees? Which trees have you planted, and where have you planted them?

Miscellaneous

1. Is there anything else I should know about this topic?
2. Is there anyone else I should talk to about this topic?

B.2 Key Informant Interview Questions

Work Background/Demographics

1. What is your position?

2. How long have you worked in this position?
3. How long have you worked in the region of Kaffrine?
4. What are your duties?
5. What proportion of your duties relate to forest management?

Roles of Office/Organization

1. How does your office track increases and decreases in forests?
    a. Using what kind of data?
    b. How often is the data collected?
2. Does your office work with local communities regarding forest use and management?
3. How does your office interact with local communities (e.g., visit villages, send newsletters, conduct demonstration projects, etc.)?

Forest Changes

1. Have the forests in your county/district/area changed in the past 10-15 years? In the past 20-30 years?
2. How have they changed?
3. Why have they changed?

Impact of Forest Change

1. How do these changes impact local communities?
2. How do these changes impact your agency/organization?

Action

1. Does your organization/office take action to prevent forest loss? How?

Miscellaneous

1. Is there anything else I should know about this topic?
2. Is there anyone else I should talk to about this topic?

C Appendix C – Nodes

Table C.1 *Nodes used for coding with NVivo 12. "Respondents" is the number of respondents that were coded for under a given node, and "References" is the total number of times a node was coded for. These numbers represent coding for both local respondents and key informants.*

Node	Nested Nodes	Respondents	References
Action	Difficulties/Deterrents	34	65
	Efforts to Prevent Forest Loss	38	120
Climate Change	-	31	53
Environmental Degradation	Agricultural Intensification	24	31
	Deforestation	51	167
	Desertification	12	17
	Soil Fertility	19	32
	Wildfires	12	23
Financial Security	-	24	42
Food Security	-	37	78
Forest Change	Decreasing Forests	46	272
	Increasing Forests	20	99
Gender Roles	-	6	8
God	-	16	22
Governance	Community	42	64
	Eaux et Forêts	16	58
	NGOs	0	0
	Peace Corps	4	4
	Village Chief	2	3
Health	Access to Traditional Medicine	19	40
	Nutrition	8	11
Land Tenure	-	0	0
Landuse Conflict	-	4	8
Natural Resource Management	Charcoalization	12	17
	Pastoralism	17	29
	Slash and Burn Agriculture	6	8
Outreach and	-	20	49
Population Change	Migration	2	2
	Population Growth	6	6
Wildlife	Decreasing Wildlife Species	8	32
	Increasing Wildlife Species	4	6
Tree Species	Decreasing Tree Species	49	257
	Increasing Tree Species	15	37
Water Security	-	34	58

D Appendix D – Decreasing Tree Species

Table D.1 *Tree species identified as decreasing or having disappeared from the landscape, arranged by number of respondents that referenced the species as decreasing. "Respondents" is number of respondents that referenced the species as decreasing, and "References" is the total number of times a species was referenced as decreasing.*

Species	Common Name (Wolof)	Respondents	References
Detarium microcarpum	Dànq	19	28
Pterocarpus erinaceus	Win	18	27
Parkia biglobosa	Néte, Wul	13	18
Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	10	14
Swartzia madagascariensis	Dimbeli	10	12
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	9	11
Lannea acida	Son	8	10
Cordyla pinnata	Dimb, Dimbu	7	11
Sterculia setigera	Mbép	6	8
Combretum glutinosum	Rat	5	5
Ekebergia senegalensis	Xak cooy	5	6
Hymenocardia acida	Enkeleñ	5	6
Adansonia digitata	Guy	4	4
Anogeissus leiocarpus	Ngejan, Gejj	4	4
Diospyros mespiliformis	Alom	4	4
Ficus iteophylla	Loro, Tat	4	6
Tamarindus indica	Dakkar	4	4
Afrormosia laxiflora (Pericopsis laxiflora)	Kulukulu	3	3
Balanites aegyptiaca	Sump	3	3
Ceiba pentandra	Béntéñe	3	3
Erythrina senegalensis	Xunjël	3	4
Faidherbia albida	Kàdd	3	3
Guiera senegalensis	Nger	3	3
Heeria insignis	Waswasor	3	3
Unidentified Tree Species	Jaxaan jaxaan	3	3
Parinari macrophylla (Neocarya macrophylla)	New	3	3
Saba senegalensis	Madd	3	3
Spondias mombin	Nimkom	3	3
Anacardium occidentale	Darkase	2	2
Cassia sieberiana	Senjeñ	2	2
Khaya senegalensis	Xaay	2	2
Parinari excelsa	Mampatan	2	3
Ziziphus mauritiana	Sidéem	2	2
Annona senegalensis	Dugor mer	1	1
Azadirachta indica	Cassia, Neem	1	1
Unidentified Tree Species	Balemboop	1	1
Boscia senegalensis	Njandam	1	1
Cola nitida	Taba	1	1
Combretum aculeatum	Sawet	1	1
Combretum nigricans	Taap	1	2
Dalbergia melanoxylon	Jalamban	1	1
Daniellia olivera	Santan	1	1
Unidentified Tree Species	Dankwell	1	1

Diospyros ferrea	Selax	1	1
Unidentified Tree Species	Dogo	1	1
Ficus capensis	Soto aldiana	1	1
Ficus congensis	Xël baroom	1	1
Ficus ingens	Sanxay	1	1
Unidentified Tree Species	Fuyufia	1	1
Unidentified Tree Species	Gaduba	1	1
Unidentified Tree Species	Gerise	1	1
Grewia bicolor	Kel	1	1
Unidentified Tree Species	Katiñankumo (Mandinka)	1	1
Kigelia africana	Ndambal	1	2
Unidentified Tree Species	Kulungkalango (Mandinka)	1	1
Lannea velutina	Songa bay	1	1
Mangifera indica	Mango	1	1
Maytenus senegalensis (Gymnosporia senegalensis)	Ndori, Ngandik, Genamdik	1	1
Mitragyna inermis	Xos	1	1
Moringa oleifera	Sap sap, Mboom, Nebedaye	1	1
Unidentified Tree Species	Mumung	1	1
Piliostigma reticulatum	Ngiigiis	1	1
Prosopis africana	Yir	1	1
Unidentified Tree Species	Sangam	1	1
Senegalia senegalia	Verek	1	1
Unidentified Tree Species	Son bu Nuul	1	1
Unidentified Tree Species	Soto a Jenax	1	1
Strophanthus sarmentosus	Coox, Soox	1	1
Unidentified Tree Species	Tabax	1	1
Vachellia seyal	Fonax (green), surur (red)	1	1
Vitex doniana	Lëng	1	1
Unidentified Tree Species	Xadijanquma	1	1
Unidentified Tree Species	Xuloom	1	1
Ziziphus mucronata	Sidéem bukki	1	1

E Appendix E – Tree Species Cited as Declining that are Also Listed on the IUCN Red List

Table E.1 *Tree species that are perceived to be in decline and are listed on IUCN's Red List of Threatened, by number of references.*

Species	Common Name (Wolof)	References	IUCN Status
Detarium microcarpum	Dànq	28	LC
Pterocarpus erinaceus	Win	27	EN
Ekebergia senegalensis	Xak cooy	6	LC
Tamarindus indica	Dakkar	4	LC
Erythrina senegalensis	Xunjël	4	LC
Ceiba pentandra	Béntéñe	3	LC
Parinari excelsa	Mampatan	3	LC
Khaya senegalensis	Xaay	2	VU
Azadirachta indica	Cassia, Neem	1	LC
Dalbergia melanoxylon	Jalamban	1	NT
Kigelia africana	Ndambal	2	LC
Vitex doniana	Lëng	1	LC

LC - Least Concern, NT - Near Threatened, VU - Vulnerable, EN - Endangered

F Appendix F – Utilization of Tree Species

F.1 Utilized Tree Species

Table F.1 *Tree species referenced as utilized by respondents, arranged alphabetically. "Respondents" is number of respondents that referenced the species as a species of use, and "References" is the total number of times a species was referenced as being a species of use.*

Species	Common Name	Respondents	References
Adansonia digitata	Guy	3	5
Anacardium occidentale	Darkase	8	10
Annona senegalensis	Dugor mer	1	1
Anogeissus leiocarpus	Ngejan, Gegg	5	5
Azadirachta indica	Cassia, Neem	5	6
Balanites aegyptiaca	Sump	7	8
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	3	3
Cajanus cajan	Nebe	1	1
Carica Papaya	Papikaya	5	6
Cassia sieberiana	Senjeñ	1	1
Ceiba pentandra	Béntéñe	1	1
Citrus spp.	Limon	5	8
Cola nitida	Taba	1	1
Combretum glutinosum	Rat	14	16
Combretum micranthum	Kenkiliba, Sexaw	3	3
Cordyla pinnata	Dimb, Dimbu	25	34
Detarium microcarpum	Dànq	4	4
Diospyros ferrea	Selax	1	1
Diospyros mespiliformis	Alom	8	10
Ekebergia senegalensis	Xak cooy	2	2
Erythrina senegalensis	Xunjël	1	1
Eucalyptus camaldulensis	Kotyl-buteel	2	2
Euphorbia balsamifera	Salan	1	1
Faidherbia albida	Kàdd	1	1
Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	4	5
Ficus iteophylla	Loro, Tat	1	2
Ficus thonningii	Dóobale	2	2
Guiera senegalensis	Nger	9	10
Heeria insignis	Waswasor	1	1
Hexalobus monopetalus	Xaasew, Xaasaw	1	1
Hymenocardia acida	Enkeleñ	1	1
Jatropha curcas	Tabanani	1	2
Khaya senegalensis	Xaay	1	1
Lannea acida	Son	3	3
Leucaena leucocephala	Leucaena	2	5
Mangifera indica	Mango	17	22
Mitragyna inermis	Xos	2	2
Moringa oleifera	Sap sap, Mboom, Nebedaye	2	2
Musa spp.	Banana	2	2
Parinari macrophylla (Neocarya macrophylla)	New	3	3
Parkia biglobosa	Néte, Wul	1	1
Parkinsonia aculeata	Parkinsonia	1	1

Prosopis juliflora	Dakkar Toubab	1	2
Piliostigma reticulatum	Ngiigiis	9	9
Prosopis africana	Yir	2	2
Psidium guajava	Guap	5	7
Pterocarpus erinaceus	Win	7	7
Senegalia mellifera	Mellifera	4	4
Sterculia setigera	Mbép	8	8
Strychnos spinosa	Tëmb	1	1
Swartzia madagascariensis	Dimbeli	1	1
Tamarindus indica	Dakkar	4	5
Vachellia nilotica	Neb neb	5	6
Ziziphus mauritiana	Sidéem	8	8
Ziziphus mucronata	Sidéem bukki	1	1
Unidentified Tree Species	Bunge	1	1
Unidentified Tree Species	Cene	1	1
Unidentified Tree Species	Dankwell	1	1
Unidentified Tree Species	Gerese	1	1
Unidentified Tree Species	Katiñankumo (Mandinka)	1	1

F.2 Use of Tree Species

Table F.2 *Tree species and associated utilization as referenced by local respondents. "Respondents" is number of respondents that referenced the species as utilized, and "References" is the total number of times a species was referenced as being utilized.*

Utilization	Species	Common Name (Wolof)	Respondents	References
Fencing			**6**	**20**
	Azadirachta indica	Cassia, Neem	1	1
	Combretum glutinosum	Rat	3	3
	Combretum micranthum	Kenkiliba, Sexaw	1	1
	Cordyla pinnata	Dimb, Dimbu	1	1
	Guiera senegalensis	Nger	2	2
	Piliostigma reticulatum	Ngiigiis	1	1
	Senegalia mellifera	Mellifera	1	1
	Sterculia setigera	Mbép	1	1
Fodder			**1**	**3**
	Pterocarpus erinaceus	Win	1	1
	Sterculia setigera	Mbép	1	1
Food			**29**	**160**
	Adansonia digitata	Guy	2	3
	Anacardium occidentale	Darkase	4	5
	Balanites aegyptiaca	Sump	4	5
	Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	1	1
	Cajanus cajan	Nebe	1	1
	Carica papaya	Papikaya	4	4
	Citrus spp.	Limon	4	6
	Cordyla pinnata	Dimb, Dimbu	18	22
	Detarium microcarpum	Dànq	4	4
	Diospyros mespiliformis	Alom	7	9
	Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	1	1
	Lannea acida	Son	1	1
	Mangifera indica	Mango	14	17
	Musa spp.	Banana	2	2
	Parinari macrophylla (Neocarya macrophylla)	New	3	3
	Parkia biglobosa	Néte, Wul	1	1
	Psidium guajava	Guap	5	6
	Sterculia setigera	Mbép	4	4
	Tamarindus indica	Dakkar	3	4
	Ziziphus mauritiana	Sidéem	4	4
	Unidentified Tree Species	Dankwell	1	1
Fuelwood			**14**	**59**
	Anacardium occidentale	Darkase	1	1
	Anogeissus leiocarpus	Ngejan, Gejj	1	1
	Azadirachta indica	Cassia, Neem	2	2
	Balanites aegyptiaca	Sump	2	2
	Ceiba pentandra	Béntéñe	1	1
	Combretum glutinosum	Rat	9	9
	Cordyla pinnata	Dimb, Dimbu	3	3
	Eucalyptus camaldulensis	Kotyl-buteel	1	1
	Guiera senegalensis	Nger	5	5
	Lannea acida	Son	1	1
	Leucaena leucocephala	Leucaena	1	1
	Mangifera indica	Mango	2	2
	Mitragyna inermis	Xos	2	2
	Prosopis juliflora	Dakkar Toubab	1	1
	Piliostigma reticulatum	Ngiigiis	6	6
	Pterocarpus erinaceus	Win	2	2
	Senegalia mellifera	Mellifera	1	1

Live Fencing			**4**	**16**
	Euphorbia balsamifera	Salan	1	1
	Faidherbia albida	Kàdd	1	1
	Jatropha curcas	Tabanani	1	1
	Leucaena leucocephala	Leucaena	1	1
	Parkinsonia aculeata	Parkinsonia	1	1
	Senegalia mellifera	Mellifera	2	2
	Vachellia nilotica	Neb Neb	4	4
Soap			**1**	**2**
	Jatropha curcas		1	1
Soil Fertility			**3**	**13**
	Anacardium occidentale	Darkase	1	1
	Balanites aegyptiaca	Sump	1	1
	Citrus spp.	Limon	1	1
	Leucaena leucocephala	Leucaena	1	1
	Mangifera indica	Mango	1	1
	Moringa oleifera	Sap sap, Mboom, Nebedaye	1	1
	Vachellia nilotica	Neb Neb	1	1
	Ziziphus mauritiana	Sidéem	1	1
Traditional Medicine			**15**	**78**
	Adansonia digitata	Guy	1	1
	Anacardium occidentale	Darkase	1	1
	Annona senegalensis	Dugor mer	1	1
	Anogeissus leiocarpus	Ngejan, Gejj	1	1
	Carica papaya	Papikaya	1	1
	Cassia siberiana	Senjeñ	1	1
	Citrus spp.	Limon	1	1
	Combretum glutinosum	Rat	3	3
	Combretum micranthum	Kenkiliba, Sexaw	1	1
	Cordyla pinnata	Dimb, Dimbu	3	3
	Diospyros ferrea	Selax	1	1
	Diospyros mespiliformis	Alom	1	1
	Ekebergia senegalensis	Xak cooy	2	2
	Erythrina senegalensis	Xunjël	1	1
	Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	2	3
	Ficus iteophylla	Loro, Tat	1	2
	Ficus thonningii	Dóobale	2	2
	Guiera senegalensis	Nger	2	2
	Heeria insignis	Waswasor	1	1
	Hymenocardia acida	Enkeleñ	1	1
	Leucaena leucocephala	Leucaena	1	1
	Mangifera indica	Mango	1	1
	Moringa oleifera	Sap sap, Mboom, Nebedaye	1	1
	Prosopis juliflora	Dakkar Toubab	1	1
	Pterocarpus erinaceus	Win	1	1
	Strychnos spinosa	Tëmb	1	1
	Swartzia madagascariensis	Dimbeli	1	1
	Tamarindus indica	Dakkar	1	1
	Ziziphus mauritiana	Sidéem	1	1
	Ziziphus mucronata	Sidéem bukki	1	1
	Unidentified Tree Species	Bunge	1	1
	Unidentified Tree Species	Cene	1	1
	Unidentified Tree Species	Gerese	1	1
	Unidentified Tree Species	Katiñankumo (Mandinka)	1	1
Wood Products			**10**	**33**
	Anogeissus leiocarpus	Ngejan, Gejj	1	1
	Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	2	2
	Combretum micranthum	Kenkiliba, Sexaw	1	1
	Cordyla pinnata	Dimb, Dimbu	3	3
	Eucalyptus camaldulensis	Kotyl-buteel	1	1
	Guiera senegalensis	Nger	1	1
	Hexalobus monopetalus	Xaasew, Xaasaw	1	1
	Lannea acida	Son	1	1
	Prosopis africana	Yir	2	2
	Pterocarpus erinaceus	Win	3	3
	Sterculia setigera	Mbép	1	1

G Appendix G – Planted Tree Species

Table G.1 *Tree species referenced as planted, by respondent frequency. "Respondents" is number of respondents that referenced the species as planted, and "References" is the total number of times a species was referenced as planted.*

Species	Common Name (Wolof)	Respondents	References
Mangifera indica	Mango	37	41
Anacardium occidentale	Darkase	19	22
Psidium guajava	Guap	18	21
Eucalyptus camaldulensis	Kotyl-buteel	14	14
Carica papaya	Papikaya	12	13
Citrus spp.	Limon	11	12
Vachellia nilotica	Neb Neb	10	12
Ziziphus mauritiana	Sidéem	7	8
Leucaena leucocephala	Leucaena	6	10
Cordyla pinnata	Dimb, Dimbu	5	5
Senegalia mellifera	Mellifera	5	7
Azadirachta indica	Cassia, Neem	4	4
Jatropha curcas	Tabanani	4	4
Musa spp.	Banana	4	4
Balanites aegyptiaca	Sump	3	3
Delonix regia	Flamboyant	3	3
Moringa oleifera	Sap sap, Mboom, Nebedaye	3	3
Unidentified Tree Species	Bombarjay	2	2
Cajanus cajan	Nebe	2	3
Ficus thonningii	Dóobale	2	2
Manilkara zapota	Sàppóoti	2	2
Parinari macrophylla (Neocarya macrophylla)	New	2	2
Parkinsonia aculeata	Parkinsonia	2	2
Saba senegalensis	Madd	2	3
Sterculia setigera	Mbép	2	2
Tamarindus indica	Dakkar	2	2
Adansonia digitata	Guy	1	1
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	1	1
Cocos nucifera	Koko	1	1
Combretum glutinosum	Rat	1	1
Detarium microcarpum	Dànq	1	1
Diospyros mespiliformis	Alom	1	1
Euphorbia balsamifera	Salan	1	1
Faidherbia albida	Kàdd	1	1
Ficus capensis	Soto aldiana	1	1
Ficus gnaphalocarpa	Soto, Gang	1	1
Ficus iteophylla	Loro, Tat	1	1
Gliricidia sepium	Gliricidia	1	1
Khaya senegalensis	Xaay	1	1
Parkia biglobosa	Néte, Wul	1	1
Prosopis juliflora	Dakkar Toubab	1	2
Phoenix dactylifera	Tàndarma	1	1
Piliostigma reticulatum	Ngiigiis	1	1

H Appendix H – Referenced Tree Species

Table H.1 *Tree species referenced throughout interviews, listed alphabetically. "Respondents" is number of respondents that referenced the species as decreasing, and "References" is the total number of times a species was referenced.*

Species	Common Name (Wolof)	Respondents	References
Adansonia digitata	Guy	9	14
Afrormosia laxiflora (Pericopsis laxiflora)	Kulukulu	3	3
Anacardium occidentale	Darkase	25	55
Annona senegalensis	Dugor mer	3	3
Annona squamosa	Pomkannel	1	1
Anogeissus leiocarpus	Ngejan, Gejj	11	12
Azadirachta indica	Cassia, Neem	8	12
Balanites aegyptiaca	Sump	9	13
Bombax costatum	Garabu lawbe, Dundul, Guy jeeri	10	14
Boscia senegalensis	Njandam	1	1
Cajanus cajan	Nebe	2	3
Carica papaya	Papikaya	14	25
Cassia sieberiana	Senjeñ	1	1
Ceiba pentandra	Béntéñe	3	3
Citrus spp.	Limon	14	24
Cocos nucifera	Koko	1	1
Cola nitida	Taba	2	3
Combretum aculeatum	Sawet	1	1
Combretum glutinosum	Rat	21	27
Combretum micranthum	Kenkiliba, Sexaw	3	3
Combretum nigricans	Taap	1	2
Cordyla pinnata	Dimb, Dimbu	31	75
Dalbergia melanoxylon	Jalamban	1	1
Daniellia oliveri	Santan	1	1
Delonix regia	Flamboyant	3	3
Detarium microcarpum	Dànq	18	29
Diospyros ferrea	Selax	1	1
Diospyros mespiliformis	Alom	11	15
Ekebergia senegalensis	Xak cooy	4	6
Erythrina senegalensis	Xunjël	1	3
Eucalyptus camaldulensis	Kotyl-buteel	16	26
Euphorbia balsamifera	Salan	2	2
Faidherbia albida	Kàdd	5	5
Ficus capensis	Soto aldiana	1	1
Ficus congensis	Xël baroom	1	1
Ficus gnaphalocarpa (Ficus sycomorus)	Soto, Gang	8	15
Ficus ingens	Sanxay	1	1
Ficus iteophylla	Loro, Tat	5	8
Ficus thonningii	Dóobale	4	5
Gliricidia sepium	Gliricidia	1	1
Grewia bicolor	Kel	1	1
Guiera senegalensis	Nger	13	16
Heeria insignis	Waswasor	5	5
Hexalobus monopetalus	Xaasew, Xaasaw	1	1
Hymenocardia acida	Enkeleñ	4	6

Jatropha curcas	Tabanani	5	10
Khaya senegalensis	Xaay	2	4
Kigelia africana	Ndambal	1	2
Lannea acida	Son	10	15
Lannea velutina	Songa bay	1	1
Leucaena leucocephala	Leucaena	6	17
Mangifera indica	Mango	43	133
Manilkara zapota	Sàppóoti	1	2
Maytenus senegalensis (Gymnosporia senegalensis)	Ndori, Ngandik, Genamdik	1	1
Mitragyna inermis	Xos	4	5
Moringa oleifera	Sap sap, Mboom, Nebedaye	6	6
Musa spp.	Banana	8	11
Parinari excelsa	Mampatan	1	2
Parinari macrophylla (Neocarya macrophylla)	New	9	11
Parkia biglobosa	Néte, Wul	13	18
Parkinsonia aculeata	Parkinsonia	3	3
Phoenix dactylifera	Tàndarma	1	3
Piliostigma reticulatum	Ngiigiis	1	15
Prosopis africana	Yir	12	3
Prosopis juliflora	Dakkar Toubab	2	3
Psidium guajava	Guap	18	34
Pterocarpus erinaceus	Win	18	36
Saba senegalensis	Madd	4	4
Senegalia mellifera	Mellifera	6	9
Senegalia senegal	Verek	1	1
Spondias mombin	Nimkom	2	2
Sterculia setigera	Mbép	11	15
Strophanthus sarmentosus	Coox, Soox	1	1
Strychnos spinosa	Tëmb	1	1
Swartzia madagascariensis	Dimbeli	9	12
Tamarindus indica	Dakkar	7	13
Vachellia nilotica	Neb neb	13	26
Vachellia seyal	Fonax (green), surur (red)	1	1
Vitex doniana	Lëng	1	1
Ziziphus mauritiana	Sidéem	14	23
Ziziphus mucronata	Sidéem bukki	1	1
Unidentified Tree Species	Balemboop	1	1
Unidentified Tree Species	Bombarje	2	3
Unidentified Tree Species	Bunge	1	1
Unidentified Tree Species	Cene	1	1
Unidentified Tree Species	Dankwell	1	1
Unidentified Tree Species	Dogo	1	1
Unidentified Tree Species	Fuyufia	1	1
Unidentified Tree Species	Gabuda	1	1
Unidentified Tree Species	Gerese	1	1
Unidentified Tree Species	Jaxaan jaxaan	3	4
Unidentified Tree Species	Katiñankumo (Mandinka)	1	1
Unidentified Tree Species	Kulungkalango (Mandinka)	1	1
Unidentified Tree Species	Mumung	1	1
Unidentified Tree Species	Sangam	1	1
Unidentified Tree Species	Son bu nuul	1	1
Unidentified Tree Species	Soto a Jenax	1	1
Unidentified Tree Species	Tabax	1	1
Unidentified Tree Species	Xadijanquma	1	1
Unidentified Tree Species	Xuloom	1	1

I Appendix I – Copyright Permissions

Figure 3.1: “Sénégal in Africa (-mini map -rivers)” by TUBS. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Sénégal_in_Africa_(-mini_map_-rivers).svg. Accessed October 2018.

Figure 3.2: “Sénégal, administrative divisions - en - monochrome.svg” by NordNordWest. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Sénégal,_administrative_divisions_-_en_-_monochrome.svg. Accessed October 2018.

Figure 3.4; Figure 3.5; Figure 4.3: Photographs used with permission of Susan Rodriguez.

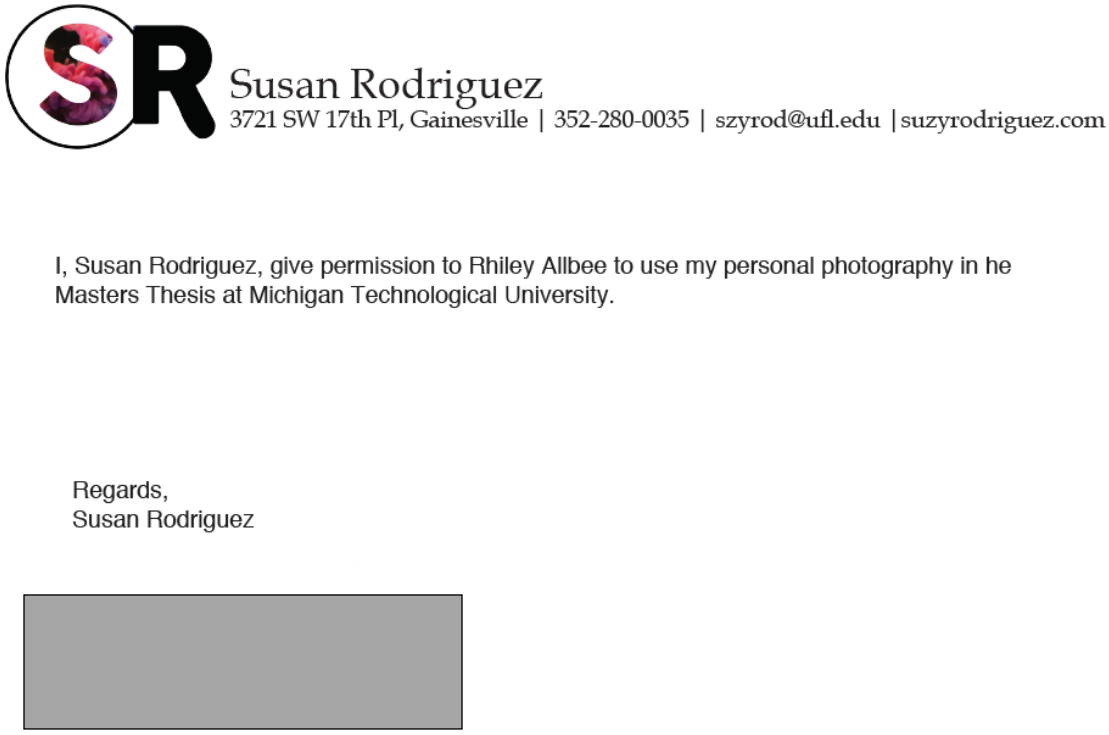
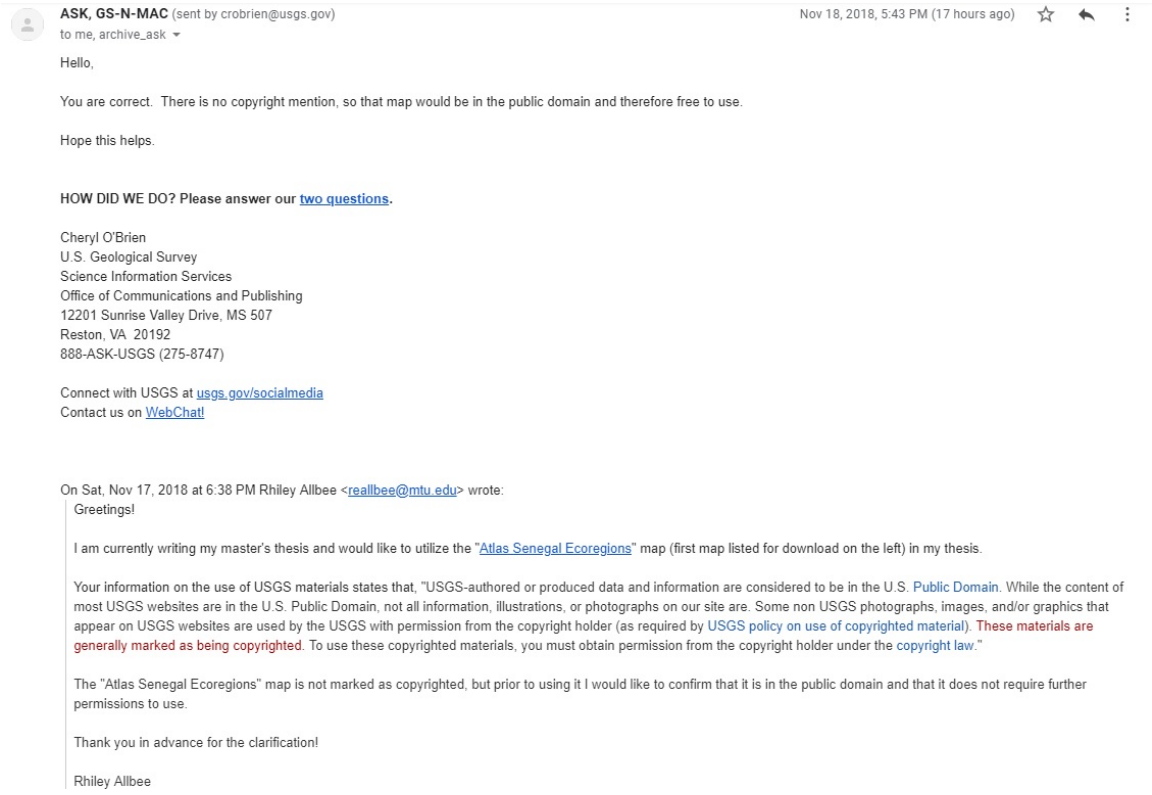


Figure 4.1: “Kaffrine in Sénégal.svg” by TUBS. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Kaffrine_in_Sénégal.svg. Accessed November 2018.

Figure 4.2: “Map of the Kaffrine region of Sénégal” by Maximilian Dörrbecker (Chumwa). Licensed under the Creative Commons Attribution- ShareAlike 2.0 Generic License via Wikimedia Commons - https://fr.m.wikipedia.org/wiki/Fichier:Map_of_the_departments_of_the_Kaffrine_region_of_Sénégal.png. Accessed October 2018.

Figure 4.5: “Atlas Senegal Ecoregions” by USGS. Image within the public domain - https://eros.usgs.gov/westafrica/ecoregions-and-topography/ecoregions-and-topography-senegal Accessed November 2018.



ASK, GS-N-MAC (sent by crobrien@usgs.gov) Nov 18, 2018, 5:43 PM (17 hours ago)
to me, archive_ask

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On Sat, Nov 17, 2018 at 6:38 PM Rhiley Allbee <reallbee@mtu.edu> wrote:

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>
> I am currently writing my master's thesis and would like to utilize the "Atlas Senegal Ecoregions" map (first map listed for download on the left) in my thesis.
>
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> Thank you in advance for the clarification!
>
> Rhiley Allbee